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ABSTRACT

Chapter I provides a background and explains pertinent library lighting problems such as quality, function, aesthetics, intensity, and costs. Emphasis is on the quality and function of lighting for library users. Chapter II deals with the comments and answers to questions by persons who have a special interest and competence in the field of library lighting or who are involved directly or indirectly in at least one of its five major aspects. The individuals consulted are listed in Appendix A. Chapter III presents the conclusions reached by the author on different aspects of library lighting, and Chapter IV contains recommendations. A major objective of the study has been to make available to those involved in planning library buildings a summary of the different points of view of the consultants who included the following: (a) Persons having first-hand experience with the planning and installation of library lighting: architects, consulting and construction engineers and contractors, illuminating engineers, and interior designers; (b) Persons with particular competence in fields indirectly involved in library lighting: opthalmologists and other physicians, one conservation expert, psychologists and reading experts, and financial and plant maintenance officers of academic institutions; and (c) Users of libraries: research scholars and librarians. (Author/NH)

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LIBRARY LIGHTING

Keyes D. Metcalf

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THE ASSOCIATION OF RESEARCH LIBRARIES

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FOREWORD

The Association of Research Libraries is pleased to present this study on library lighting. Through groups or committees of its members the Association has long been concerned with problems involved in the planning and design of academic library buildings. Ten years ago when preparations for Mr. Metcalf's book, *Planning Academic and Research Library Buildings*, were being made, the Association of Research Libraries and the American Library Association jointly appointed an advisory committee and cosponsored the work.

Thus when it became apparent that the lighting of library buildings presented such special problems that it would be desirable to have a report for use by librarians and administrative officers, the Association, aided by funds from the Council on Library Resources, Inc., welcomed the opportunity to serve as the sponsor.

Keyes D. Metcalf, dean of library consultants, was the obvious first choice as the man to carry out the investigation and prepare the report. The Association was fortunate in Mr. Metcalf's acceptance of the assignment. Although Mr. Metcalf needs no introduction, it may be useful to recall that his concern with library lighting now extends over a period of more than half a century. In that time he has seen library lighting go from a few footcandles (if it were measurable at all) to the 100-plus footcandles found in some libraries today.

But Mr. Metcalf has been considerably more than an observer of the library lighting scene. He has read and studied much of the literature on the subject and has contributed to it. In his career as a librarian he has been responsible for developing programs for lighting new library buildings and relighting existing buildings. Particularly in the past fifteen to twenty years, during which he has served as consultant to hundreds of library building projects in this country and abroad, Mr. Metcalf has been deeply concerned with the provision of high quality lighting adapted to the various functions carried on in libraries. These consulting appointments have provided the opportunity to exchange views and information on library lighting with many librarians, architects, and engineers from all parts of the United States, Canada, and Australia.

For the past two years Mr. Metcalf has been a regular participant in the meetings of the Subcommittee on Library Lighting of the Illuminating Engineering Society. This subcommittee has been engaged in preparing the section on library lighting to be published in the fifth edition of the Society's *Lighting Handbook*.

Although the Association of Research Libraries has sponsored this study and an advisory committee of its members has given such assistance as it could render, the conclusions and recommendations of the report are those of the author. The Association, as an organization, takes no position on these matters.

The Association is pleased to express its indebtedness to Mr. Metcalf for his skill, his patience, and his diligence in carrying out a task that, in the event, became far more complex and time-consuming than was envisioned at the outset. The Association is under obligation as well to the respondents who freely contributed their time, experience, and knowledge by recording their views on various aspects of library lighting.

Members of the advisory committee assisted in planning the study, suggesting potential respondents, and reviewing and commenting on the report in its various drafts.

The Association gratefully acknowledges the grant from the Council on Library Resources which made the study possible.

Stephen A. McCarthy
Executive Director
Association of Research Libraries

April 17, 1969

PREFACE

This report grew out of an interest in library lighting on the part of the Association of Research Libraries and the Council on Library Resources, Inc. This joint concern resulted in an application from the Association for a small grant by the Council to finance a nontechnical study of the subject. The grant was made in the autumn of 1967, and the Association of Research Libraries asked the writer to conduct the study. After hesitation because of prior commitments, his previously published work in the field, and his advanced age, he accepted the assignment with the understanding that an advisory committee of librarians with extensive experience in planning library buildings would be appointed to work with him.

In January 1968, at the time of the Bal Harbour, Florida, midwinter meeting of the Association of Research Libraries and the American Library Association, the method of approaching the problem was agreed on. With the help of the advisory committee, it was decided to enlarge the scope of the study by inviting persons from many different groups which were directly or indirectly involved in lighting problems to answer pertinent questions and to comment freely on library lighting. As one might expect, their responses yielded a wide variety of opinions that can be summarized but in many cases cannot be reconciled. The involvement of so many specialists also complicated the report and delayed its completion.

The names of the persons who contributed directly or indirectly to the report are listed in Appendix A. Most of them answered specific questions put to them by letter or responded to requests for general comments on the aspects of library lighting with which experience or special training had qualified them to deal; a number of them did both. Some helped through personal interviews and others through their published writings. Agreement among the consultants would have indicated that they had not been well chosen, and would have decreased the value of the report and narrowed its scope. Each of them, whether or not he agreed with the writer's conclusions and recommendations, deserves grateful acknowledgment and hearty thanks. A special debt is owed to the members of the advisory committee: Dr. Gustave A. Harrer, director of the University of Florida Libraries at Gainesville; Dr. Stephen A. McCarthy, executive director of the Association of Research Libraries; Dr. Robert H. Muller, professor, School of Library Science, University of Michigan; Dr. Edward B. Stanford, director of libraries at the University of Minnesota; and Mr. David C. Weber, director of the Stanford University Libraries. All of them suggested persons to be consulted and read and commented on the text in its earlier drafts. Since they did not, however, completely agree with one another or with the author, they should not in any way be held responsible for the conclusions and recommendations in Chapters III and IV.

Willard W. Thompson and James F. Clapp, Jr., both of whom have been involved in a large number of library projects, have gone over the report in detail, discussed it with the writer, and corrected many errors; like the other consultants, however, they should not be held responsible for the conclusions or the recommendations.

Edwin E. Williams, an associate director of the Harvard University Library, came to the writer's rescue as he has many times in the past and edited the report. Mrs. Esther MacSwan patiently typed and retyped the text numberless times.

Without the aid of the Council on Library Resources, which financed the project and accepted without complaint the long delay in its completion, and that of the sponsor, the Association of Research Libraries, through its executive director, Dr. Stephen A. McCarthy, the enterprise could never have been completed.

INTRODUCTION

Throughout the century the part played by libraries in educational programs has grown in importance as their research collections have been developed. This growth has been particularly apparent since World War II. To say that a library is the heart of an educational institution may be trite, but this does not mean that it is not true. There may be those who feel that libraries have become unduly expensive, but the fact remains that on the average libraries now consume no larger a percentage of the total educational budget than they did a generation ago, in spite of the fact that they are more heavily used and maintain better public-service staffs, better catalogs, and much larger and more adequate collections. It follows that libraries require larger and better equipped buildings, which inevitably cost large sums of money.

What does this have to do with library lighting? Lighting is an important part of the whole library situation. To provide good library service in line with other college and university activities may cost some 5 percent of the institution's total academic budget. Because of the extensive accommodations required for readers, service to them, and storage for the collections, library facilities may occupy up to 10 percent of the total square footage of the institution's building space. If the cost of the book stock and its processing is included, the library represents a still larger proportion, perhaps up to 15 percent, of the total capital investment in the institution's educational plant and equipment.

If full value is to be received from this large commitment, a library building should provide functional, attractive, and comfortable quarters for all kinds of library use, including study facilities for students if, as is usually the case, dormitory rooms afford poor places in which to study. (The construction of satisfactory study accommodations in the library generally will be less expensive—even if this means provision of seating for from one-fifth to as much as one-half of the total student body—than the provision of these accommodations in dormitory rooms. For many students, if not for most, a well planned and well staffed library is the best place to study because of its quiet atmosphere and the presence of reference materials which often will not be used unless immediately at hand.)

Satisfactory lighting is essential in a library. But what is a satisfactory lighting installation? Is it one that occasions few complaints, or one that can simply be described as adequate? Should it be of the highest possible quality throughout the building, or can there be skimping in little-used areas and in those where intensive reading does not take place? What intensity of light should be provided? Good lighting for one person may not be satisfactory for another. Many readers pay little attention to the lighting, good or bad; they are used to accommodating themselves to different kinds and types of light, different in quality and quantity and used for

different activities, and they tend to accept the given environment. Natural light presents the greatest extremes. A bright sun on freshly fallen snow may be a pleasant sight, but many persons find difficulty in adapting their eyes to the sudden exposure of intense light, and it would not be suitable for reading. On the other hand, a dull day can make it difficult to read even large print in an all-glass building without the aid of artificial light.

It might be fair to say that artificial light is required in the average library for at least half of the hours the building is in use; in fact, during recent years it has become customary in most libraries to keep lights on in all areas used by the public whenever the building is open.

"Reading Areas in College Libraries," a recent study by Robert Sommer published in the July 1968 *Library Quarterly*, summarizes the responses of 1,112 students at 16 colleges and universities who were questioned about specific aspects of library environment. A large percentage of these students regarded the lighting in their libraries as excellent or satisfactory. (Among other factors, students were asked to consider such aspects as ventilation, temperature control, comfort of chairs, floor coverings, room size, smoking facilities, and so forth.) Fifty percent of these students reported that library lighting was excellent, and an additional 40 percent said that it was satisfactory. Only 10 percent indicated a need for improvement, and at least some of these students may well have been using old buildings with badly out-dated installations. Ventilation represented a much less satisfactory feature of the environment, with only about a quarter of the students reporting excellent conditions. A somewhat similar response was given to questions on other facilities.

Yet lighting remains the most controversial problem that the writer has found in his work with librarians, architects, and building committees, both in planning new library buildings and in renovating and adding to old buildings. Quality, aesthetics, functional aspects, intensity, and costs are all involved, and each of these factors is affected by the others.

The writer is neither an engineer nor an architect and often gets beyond his depth in technical problems, but he has been interested in library lighting for many years. It is hoped that the nontechnical character of this study will make it intelligible and useful to laymen, particularly to university and college administrative officers, faculty building committees, librarians, and architects.

Chapter I, which provides a background for the ensuing chapters, discusses and tries to explain the library lighting problems which seem pertinent, such as quality, function, aesthetics, intensity, and costs. Emphasis is placed on the quality and function of lighting for library users rather than on aesthetic aspects, intensity, or costs, although the last two are discussed in detail as they are definitely part of the problem and are highly controversial.

Chapter II deals with the comments and answers to questions by persons who for one reason or another have a special interest and competence in the field of library lighting or those who are involved directly or indirectly in at least one of its five major aspects. The individuals consulted are listed in Appendix A.

Chapter III presents the conclusions reached by the writer on different aspects of library lighting, and Chapter IV contains recommendations. The writer takes full responsibility for both the conclusions and recommendations of the study.

A major objective of the study has been to make available to those involved in planning library buildings a summary of the different points of view of the consultants who included the following:

a. Persons having first-hand experience with the planning and installation of library lighting: architects, consulting and construction engineers and contractors, illuminating engineers, and interior designers;

b. Persons with particular competence in fields indirectly involved in library lighting: ophthalmologists and other physicians, one conservation expert, psychologists and reading experts, and financial and plant-maintenance officers of academic institutions; and

c. Users of libraries: research scholars and librarians.

The other objectives have been to record in nontechnical terms the conclusions reached by the writer after a study of the relevant literature and after consultation with those referred to in the preceding paragraphs, and finally to state his recommendations in regard to installations of library lighting.

Since the report is nontechnical in character, it has little to say about the relative merits of polarized lighting, incandescent bulbs, fluorescent tubes, mercury-vapor or sodium-vapor lamps, except as they relate to quality, function, intensity, and costs. Technical information is available in the Illuminating Engineering Society's *Lighting Handbook* and from consulting and illuminating engineers. The report does not discuss color in its relation to aesthetics. Like other aesthetic problems, color is a matter of taste and to some extent of current styles, although it undoubtedly has other important aspects in lighting. The basic lighting problems to be considered here are quality, function and flexibility, aesthetics, the suitable intensity of light, the costs of lighting installations and their operation and maintenance, and finally the relation of all these factors to each other.

The writer has tried to be objective in his consideration of controversial matters. His basic position is this: To provide good library services and facilities is so expensive and so important that good lighting, which is a very significant factor in encouraging use of the library, is well worth what it may add to the total capital outlay for the building and to current operating costs. An attempt to save a small fraction of the total cost by

skimping on lighting may seriously reduce the value of the whole project. Funds are limited and choices must be made, but it is penny wise and pound foolish to economize at the expense of good lighting.

CHAPTER I

LIGHTING PROBLEMS

Quality

Quality in library lighting is as difficult to define as quality in any field. If one strives for quality, among the questions to be considered are these:

1. What is the effect of the quality of light on eye fatigue?
2. What is its effect on studying, reading, reading speed, and comprehension and retention of the material read?

It is generally agreed that the higher the quality of lighting, the less one is aware of its source. Many readers seem to prefer fairly uniform intensity throughout the reading areas. But others—particularly older scholars—prefer to have local lighting coming over the shoulder to supplement general lighting of relatively low intensity. Local lighting, unfortunately, has been found to present problems of maintenance and repair: vandalism, carelessness, and disregard for public property may make it inadvisable in many areas in an academic library.

Quality of lighting comprises much more than the avoidance of too high or too low intensities. It involves lighting without glare, reflection, or shadows on the working surface, or great contrasts between the surface and the surroundings—that is, the windows, the walls, the ceiling, and the floor. The working surface refers here to the desk, tabletop, or the book held in the reader's hand. Quality of lighting provides a satisfactory intensity for the task performed. No one who was consulted questioned any of these factors, although many believed it is relaxing and restful for the reader to be able to look out on a pleasant scene, even if a luminescence contrast ratio which would not otherwise be agreeable results. Direct light shining in the eyes is undesirable, of course, whether it be natural or artificial.

There is general agreement, even by the advocates of high intensity and of the constantly increasing intensities often recommended today, that quality is on the whole more important than intensity and that poor quality light, with glare and reflections and shadows on the working surface or with light shining in the eyes, is even more objectionable than low intensities, such as the 10 to 20 footcandles in common use between the two World Wars, which are no longer considered adequate for reading.

How is quality lighting achieved? What are the things to watch for if it is to be improved?

1. *Glare and reflection:* Glare and reflection result from a strong light shining directly into the eyes or coming from a direction that strikes any surface, particularly a shiny or glossy one, at an angle that channels reflections into the eyes. The higher the intensity of the light when it strikes a surface and the shinier the surface, the greater the glare and the more troublesome the results. Even though extra care is required to provide quality light when high intensities are used, higher intensity need not be avoided if it improves the quality of the results, as it often can do with a good installation. Indeed, one reason for the use of higher intensity is that it can now be provided satisfactorily; with the availability of better fixtures it is no longer difficult or even impossible as it once was to place the light sources where they must be in order to provide the quality desired. (The writer was told by a lighting expert in the late 1930's that it was physically impossible to provide high quality lighting in a room with an 8-foot ceiling, a height which today is in common use.)

Even so, high intensity when combined with high quality inevitably adds to the cost. One reason is that improved quality almost automatically reduces intensity: that is, the more the light source is protected in order to avoid glare and reflections and to obtain desirable indirect lighting or diffusion, the greater the reduction in the intensity. Fortunately, properly finished light-colored tables, walls, and floors tend to increase intensity on the working surface and to reduce the contrast ratio. They need not give undesirable reflections as they too often used to do even with low intensities. Lamps now on the market make it possible without sacrificing quality to provide several times as much intensity as could be achieved satisfactorily 50 years ago.

2. *Great contrast:* Contrast ratios that are greater than 5 to 1 between the intensity of light on the material being read and the working surface and its surrounding walls, windows, ceilings, partitions, and floors are usually undesirable. Uncomfortably large contrast ratios result from direct sunlight, daylight, glare, or reflections from fresh snow or light-colored nearby buildings. Light coming from outside through windows or skylights can generally be adequately controlled by horizontal or vertical venetian blinds, screens, shades, curtains, louvers, fins, or building overhangs, and to some extent by tinted glass. None of these devices, with the exception of tinted glass, will be useful unless they can be adjusted to keep out the direct sunlight, particularly on the west when the sun is low. During much of the year the southern exposure can be troublesome in the northern hemisphere. It may be desirable to use devices that when not needed for protection from sunlight can be adjusted to make available pleasant views of the outside. Undesirably large contrast ratios can also result with high intensities from artificial light and from shadows that may be produced by either natural or artificial light sources.

3. *Shadows on the working surface:* Shadows may result from several

causes, and they affect quality because they provide undesirable contrasts on the working surface or between the working surface and the surroundings. Partitions and shelves on carrels frequently produce shadows. Lighting fixtures which are too far apart—8 to 10 feet, for instance, or even considerably less if the ceilings are low—often cause carrel partitions to cast shadows unless the lamps are in just the right position and the carrels are placed to match them properly; and flexibility is reduced if this must be done. Shadows are caused by full standard-height shelving of any kind that obstructs the light before it reaches the vertical sides of the shelving or working surfaces. Such shadows often result when two high ranges of shelving used for current periodicals and reference volumes are placed between the fixtures. A similar situation may occur when seating accommodations, particularly carrels with shelves and partitions, are adjacent to shelving or interspersed with it. Intermittent shadows can be produced by direct sunlight shining through tree branches and leaves. Shadow problems can also result when the light sources are widely separated rectangular blocks, even though each block may have multiple light sources which increase total wattage to a point that would otherwise be entirely adequate. In this connection, if the ceilings are high enough, the light has a better opportunity to spread and there is less likelihood of undesirable shadows. At the same time, however, intensity on the working surface is decreased by the square of the distance between this surface and the lamps. The concentration of wattage in fewer fixtures reduces installation costs, but a more expensive, completely luminous ceiling prevents most shadows and may provide better quality.

Functional Aspects of Lighting

The quality of lighting cannot be appraised without reference to the purpose it serves. Quality is not good unless the intensity is suitable for the use to which it is put. What is quality lighting for one area in a building may be unsatisfactory for another. Exhibition cases, bulletin boards, consultation tables for catalog cards, reading areas for microforms, manuscripts and archives, and maps, as well as general reading and studying areas—each may be well served by lighting that would not be completely functional and suitable for some of the others. The type of use should be taken into account in deciding on the intensity of light to be provided, its sources, and the direction from which it comes. We often strive for uniform intensity of light throughout a building, but are we sure that this is necessary or desirable? Complete uniformity is obviously unnecessary and usually impossible. There is no need to provide enough light for reading in places where no one will read, such as vestibules, lobbies, and corridors, unless they are used for exhibition purposes as well as for passageways. Lighting bright enough for reading is not necessary for rest rooms

and toilet facilities, although for the sake of cleanliness these should be better lighted than they sometimes have been. Bright entrance vestibules and lobbies can in some cases be useful in attracting patrons. This factor may be important in a centrally located municipal public library adjacent to brilliantly illuminated retail stores. In academic libraries, however, there is often an advantage in illuminating the entrance vestibules and lobbies with light of lesser intensity than that used in the reading areas: if the reader's eyes adjust to a fairly low intensity when he enters the building, lower intensity will prove more adequate in reading areas than if they were approached from a brightly lighted entrance. To go from bright light to one of lower intensity tends to be unsatisfactory if one is planning to read, because the eye adjusts more slowly from bright to dark than the other way about.

Maps, particularly large ones with small type, on large sheets that are awkward to handle, may require higher intensity for comfortable use than most books. Pencil writing in manuscripts or in the reader's own notes, particularly if written with a hard pencil, is more difficult to read and requires higher intensity than good large type. Poor carbon copies are also difficult to read. In a research library there may be difficulties with books discolored from age, printed on poor paper or in small type. Microforms of various kinds present special problems if intensities are high.

Because of the uncertainty of future requirements, flexibility is an important consideration. A tendency to aim at complete flexibility has resulted in installations which provide throughout an intensity of light that will be sufficient for any use. High intensity lighting is not harmful to the eyes, unless carried to a greater extreme than can be found in libraries at present, and it yields more complete flexibility, but the cost of providing it without reducing its quality may be great enough to be a matter of concern. The question of the relation between intensity and cost will be dealt with in more detail in the last part of this chapter.

Another functional lighting problem in libraries is the damage to paper and bindings that can come from the ultraviolet rays produced by either natural or artificial light. Natural light (sunlight) presents the most serious danger. Books should not be exposed to it. Fluorescent tubes are less of a hazard than sunlight; if they are protected, preferably by a suitable plastic covering, they should be satisfactory. (In a collection of heavily used current books which can be regarded as expendable this is no problem.) In earlier years incandescent bulbs were safer than fluorescent tubes because of their color properties, but today with the availability of color in the latter, there is little choice. There seems to be no evidence at present that mercury-vapor or sodium-vapor lamps are helpful in this regard. But it should be kept in mind that exposure of paper to light and to heat produced by light accelerates paper deterioration, one of the most serious problems faced by research libraries today.

Exhibition cases present a special problem. It may be desirable to call attention to their contents by giving them more light than the surrounding areas, but high intensity deteriorates paper, particularly if the light has ultraviolet rays from which insufficient protection is provided. Direct sunlight, as already stated, is most harmful, but fluorescent and incandescent lamps require protection by plastic or special glass. These reduce the intensity but not the heat that comes from the light, and heat, it should be remembered, is harmful. In fact, any exposure to light or heat is harmful, and the longer the exposure, the greater the resulting damage. The National Gallery of Art in Washington, the Metropolitan Museum of Art in New York City, and the National Bureau of Standards have pioneered the investigations in this field.

As lighting problems are studied in depth, it becomes more and more evident that quality, function, intensity, aesthetics, and cost are very much intertwined, and there is no single solution which can be applied with complete satisfaction to all libraries or even to all parts of one library.

Lighting and Aesthetics

The aesthetic problems of lighting are fully as difficult as the other areas. In Chapter II, statements from architects and interior designers who are particularly concerned with these aspects are quoted. If we were willing to disregard aesthetics and accept a factory-like atmosphere, satisfactory lighting from a strictly functional standpoint might be relatively simple and inexpensive. It is fortunate that few institutions are satisfied with this; a great majority are willing to pay for something that will look better and help to create a satisfactory environment for study. Although the functional and quality aspects are generally considered first, the aesthetic effects of lighting are important. They are part of the architect's basic concept for the building and are generally considered his responsibility. (He may delegate this responsibility to an illuminating engineer or to an interior designer selected by himself or the institution for which he is working. Color in light sources has been mentioned as a functional matter; it also has aesthetic aspects, but these have been regarded as falling outside the scope of this study, in part at least because they are largely a matter of taste and personal opinion.)

Experts in cost-estimating report that when asked to suggest ways to reduce the cost of unanticipated high bids, savings in the lighting installations are often the easiest to find and seem more acceptable to institutions than any others; sometimes, it is to be feared, the results are unfortunate both aesthetically and functionally.

Intensity

The question of what light intensity should be provided on the

working surface—that is, the desk or tabletops or the book held in a reader's hands or lap—appears to be the most controversial problem in library lighting. Some illuminating engineers, physicists, and representatives from other groups cooperating in this study tend to believe that the intensity is the most important single factor in lighting. But some architects, engineering experts, interior designers, ophthalmologists, psychologists, librarians, scholars, and students believe that intensity can be overemphasized and that the questions of quality and function discussed in the previous sections are more important. Almost everyone admits that the aesthetic results and costs should not be left out of consideration, but some persons deprecate an emphasis on costs of installation and operation, believing that these are of secondary, although not of minor, importance.

Perhaps one reason for the emphasis on intensity and costs is that they can be measured, expressed in figures, and compared. At any rate, the following points about intensity may be worth mentioning.

The intensities in regular use in libraries have increased steadily since early in the century, when one and one-half to two footcandles were the average found on library reading tables, unless the reader was fortunate enough to sit with a book directly under a table lamp or where natural light was available. No one today would claim that this lighting was adequate. But with the high ceilings then in vogue, with incandescent bulbs which were much less effective than lamps now available, and the high cost of electric current, these low intensities were almost unavoidable.

The writer's volume, *Planning Academic and Research Library Buildings*, published by McGraw-Hill in 1965, went into some detail about the steady increase in recommended intensities from 1900 to 1965: they doubled every 10 years in the earlier decades of this period. The increase may have been slower since 1950 as far as cumulative percentages are concerned, but the increase in footcandles in common use has been greater. In other countries architects and illuminating engineers recommend about one-half the intensities recommended in the United States.

Incidentally, it is not unusual today to have 125 footcandles called for in the program presented to the architect. In two instances known to the author this intensity was erroneously specified as a requirement for government grants for academic library construction.

In all figures dealing with light intensity, it is important to note whether they refer to the situation when new tubes or bulbs are installed or to what is called "maintained intensity" which is supposedly the minimum allowed before the sources are cleaned or replaced. In this study it is the maintained intensity that is referred to unless otherwise stated.

Intensity decreases primarily because of two factors. The first is light-source deterioration which may amount to 12 to 25 percent within 6 months. The more hours the light sources are used and, in the case of fluorescent tubes, the more times they are turned on and off, the more

rapid the deterioration. The deterioration continues until the lamp finally burns out or is replaced. One means of reducing loss of light is to replace lamps at regular intervals, instead of when they burn out. The second factor is dirt and its effect on the lamps, the fixtures, and the surroundings. The amount of dirt depends partly on the efficiency of the air conditioning and air filtering and partly on the quality and frequency of cleaning. Dust and dirt may ultimately take away another 25 percent of the intensity and, when combined with lamp deterioration, may bring the intensity down to two-thirds or less of what it was when everything was fresh and new.

Adequate intensity in a library lighting installation is affected indirectly by the intensity coming from the natural light that is available on a sunny day, particularly if there is a large amount of glass on the south facade and to a lesser extent, depending on the latitude, on the other sides of the building. A person sitting where the sun brightly illuminates working surfaces inevitably feels that the interior of the building, where only artificial light is available, is too dark; as a result a higher than normal light intensity may be required throughout the building, even during the hours when the natural light is low or nonexistent.

While some people object to studying in a building without windows, attractive reading areas without them may be as heavily used as those with natural light. The type of seating accommodation, the ventilation, and the quality of the artificial lighting may be more important than windows. It is easier to control the quality and intensity of artificial light than of natural light, but windows undoubtedly have good psychological effects and are recommended by most architects, though not all. Some readers and some staff members will insist on windows in the areas where they study and work.

While there is uncertainty about some aspects of the relationship between intensity and quality, there is general agreement that increased intensity decreases quality unless care is taken to prevent the glare and reflections that can result from inadequately protected light sources. If quality is not neglected, however, it is possible to use the higher intensities without complications, except those entailed by higher costs for electric current and by the need to remove the heat generated by the lights. For reading situations where the materials read have very small or poor type and are difficult to see, extra high intensities are useful if not essential. Such intensities are also important in facilities used by persons with visual handicaps.

Lighting Costs

If the expense of operating and maintaining a library lighting installation is added to its initial cost, the total is large. Costs of installation

represent a capital investment; costs for maintenance and operation, which must come out of the institution's annual budget, are probably more important in most cases.

The expenditures for installation or construction are generally considered a part of those for general construction and are not always reported separately in the building budget. In most cases the amount ranges from 3 to 8 percent of the total construction cost. This wide variation depends largely on the following seven factors:

1. The wage scale for the available electricians, which varies greatly from place to place and is not always closely related to other construction costs.

2. The complexity of the wiring system. For instance, if there is a separate light switch at the end of each stack aisle and a correspondingly large number of switches throughout the building, installation costs are increased. If all the lights on each floor, or large sections of it, have only one switch, a considerable reduction results. The effect of a simplified arrangement may be, however, to increase the cost of operation and maintenance of both lighting and air conditioning because unused lamps are kept on. Time switches in stack aisles will help, but these tend to be expensive and, in the case of fluorescent lamps, to hasten tube deterioration and increase maintenance costs. Time switches are also a nuisance if they turn off while a reader is using the light.

3. The number of tubes or bulbs used in each fixture. Large fixtures, either chandeliers with incandescent bulbs or large rectangles with fluorescent tubes, decrease fixture costs. One large fixture costs less than 4 smaller ones, and less wiring is required. The large fixtures may be satisfactory in rooms with a high ceiling where the light can spread at a good angle and still provide the desired intensity. At the same time it must be remembered that the greater the height of the lamp above the working surface, the greater the decrease in the intensity on the surface. The question of wiring may be summed up by saying that, other things being equal, fewer switches and fixtures mean lower costs of installation, but the effect on quality and general effectiveness should not be overlooked.

4. The number of footcandles provided at table height. This factor is affected by the distance of the lamps from the working surface.

5. The ingenuity of the architect or his engineers in laying out the installation, and the type of construction and style of architecture. Anything that simplifies the installation tends to lessen the cost.

6. The effectiveness and efficiency of the fixtures and lamps. Some provide greater intensity with the same wattage as others, and well selected ones may provide better quality light. At the same time they may reduce intensity by protecting the source and cutting off the direct luminance that too often results in glare and reflections.

7. The cost of the fixtures. Fixtures vary widely in price, quality, and

in aesthetic effects. Simple and completely plain ones may increase intensity yet reduce quality, although this is not necessarily the case. With present-day low ceilings, protection from the lamps by baffles or plastic covering may be a necessity in order to prevent glare, to say nothing of paper deterioration.

A consulting firm of cost engineers suggests that an inexpensive installation in New Jersey in 1968, providing 30 footcandles with fluorescent lamps, would cost $1.06 per square foot in a building of 100,000 square feet. If 100 footcandles were to be installed, the cost would be $1.62 per square foot for the lighting, or $162,000. It would be easy to add to either the $106,000 or the $162,000 figure with different fixtures and wiring layouts. If construction costs come to $30 a square foot, or a total of $3,000,000, it follows that even the less expensive installation accounts for more than 3 percent of this total.

Maintenance and operating costs may or may not be considered a part of the annual library budget. In most academic institutions they are lumped with other physical plant expenditures and not charged against the library. When this is the case, the librarian and the heads of other departments may pay little attention to the costs of their installations, leaving the responsibility to the building and grounds department. The operating and maintenance costs in question can be separated into two categories, one for electric current and the other for maintenance.

The total cost of the current used for lighting depends on the following four factors:

1. The intensity of the light provided. The distance from the working surface at which lamps are placed affects the amount of current required to provide a given intensity. Lamps 30 to 50 feet above working surfaces require more current than lamps 6 to 8 feet above desk tops. Thus, high ceilinged, prewar monumental reading rooms will use more current, to obtain the same intensity, than modern reading rooms with their lower ceilings. Even less current is required in book stack carrels where the distance between lamp and desk top may be as little as 5 or 6 feet. There is a tremendous variation in maintained light intensities provided at the working surface level in libraries. In prewar buildings that have not been rewired, the intensity may be as low as 10 to 15 footcandles. In postwar buildings it now generally ranges from 35 to 125 footcandles.

2. The total wattage required to produce the desired maintained intensity. This is affected by the type of lamp and fixture and the physical aspects of the building. Incandescent bulbs provide only from 25 to 40 percent as many footcandles per watt as efficient fluorescent tubes, but may still be functional and attractive in some areas. The effectiveness per watt varies widely. Some types of fluorescent 40-watt lamps can produce a much higher intensity than 40-watt cold cathode or slim-line lamps, which are difficult to find these days, although both of them have certain other

advantages. This problem is a highly technical one and should be discussed with the engineer. The maintenance program and the type of fixture should also be taken into consideration. The wattage required to produce a given intensity will be affected if polarized light is used, and requirements also vary if mercury-vapor, sodium-vapor lamps, or other innovations are adopted.

3. The number of hours the available wattage is used. Most academic libraries observe long hours of opening, and much of the cleaning and maintenance work is done at night after the library closes. In many libraries today most of the lights are on all day, even on a bright day, and much of the night, particularly if there are open-access stacks and fluorescent tubes. It is generally not economical to turn off fluorescent lamps for periods of less than 2 hours. The average time during which lights are used in academic libraries may vary from less than 2,500 hours a year to 8,760 hours when lights are kept on 24 hours a day as they are at Stanford University.

4. The price per kilowatt the institution pays for electric current. This varies according to the local situation and is often affected by the quantity used. It may be as little as one-half cent or as much as $.02.

Possible differences in the total cost of current used for lighting may be illustrated in this way. If lights are hung no more than 8 feet above the tables, with light-colored working surfaces, walls, ceilings, and floors, and fixtures with efficient reflectors are used, one watt of current for every square foot of area can provide a good quality of light of 25 maintained footcandles. Five watts per square foot may provide 125 footcandles. If the less expensive lighting—providing one watt for each square foot per hour—is used 3,000 hours a year, 3 kilowatts will be used for each square foot. If the more expensive installation requiring 5 watts per square foot is used for 5,000 hours a year, 25 kilowatts will be used per square foot in a year. If the cost of the electricity is one-half cent per kilowatt, the annual cost can be as little as $.15 a square foot; if the cost is one and one-half cents a kilowatt, with the increased intensity and longer use, the total may be 25 times as great, or $3.75 a square foot. Thus the operating costs for lighting a building of 100,000 square feet can range from $1,500 to $37,500. These figures are used to show the extremes, not to advocate the less expensive operation. One watt per square foot, providing 25 footcandles, is substandard today and would probably not be regarded as satisfactory. Few libraries are able to manage with their lights on as little as 3,000 hours a year. Most libraries pay more than one-half cent a kilowatt for current. Hence, $1,500 per year for a building of 100,000 square feet is considerably less than should be expected; $37,500 is probably as extreme in the other direction. It should be remembered that these figures do not include the cost of maintenance. The cleaning and replacement of the fixtures and the lamps and the repair bills for the installation discussed

below, may add as much as 50 percent or more to the total budget for lighting.

As distinguished from costs for electric current, maintenance costs are those incurred in keeping lighting intensity up to the "maintained" level. This level is often considered to be about two-thirds of the intensity that is available when both the fixtures and lamps are new and clean. The causes for the decrease in intensity, which include fixture and light-source deterioration from age, dirt, and dust, were described in the "Intensity" part of this chapter. The cost of holding the intensity to the maintained level depends on how much the lamps cost and how long they last, the wage rates of the men assigned to the task, and the time required for replacing and cleaning the lamps and refurbishing the fixtures. The cleaning cost is affected, of course, by the type of fixtures used and by the dirt in the air, which can be partially controlled by an air filtering system. Those fixtures that are easiest to clean may not be satisfactory in quality or appearance. Two methods of estimating the total cost of maintenance can be illustrated by examples drawn from Southern Illinois University and from Harvard.

Southern Illinois University reports that lighting maintenance and operating costs there came to 29.11 percent of the total building costs for janitorial service, heating, air conditioning, and other uses of power. Of this sum 18.75 percent was for current and 10.36 percent for maintenance. The percentages in other libraries would vary because costs of the various factors differ, but this type of record keeping gives one a basis for estimating. Fifteen years ago at Harvard University estimates were made that the cost of cleaning, maintenance, and repairs came to one-third of the cost of electric current used throughout the University, the latter being considered one and one-half cents per kilowatt hour. The maintenance cost at one-half cent per kilowatt hour was fixed, and each building was assessed $.02 for each kilowatt used to pay for the current and maintenance. In 1969 the proportion allocated to maintenance would undoubtedly have to be increased, since kilowatt hour charges have been relatively stable while labor costs have risen.

For the purpose of illustrating the annual operating and maintenance costs of a lighting installation, let us assume a total annual maintenance cost of $1.00 per square foot—a conservative figure—for a building of 100,000 gross square feet. If electric current for lighting constitutes 20 percent of the total maintenance cost ($.20 per square foot), and maintenance of fixtures another 10 percent ($.10 per square foot) the operating and maintenance costs of the lighting installation will amount to $30,000 per year, $20,000 for current and $10,000 for maintenance.

By modifying the above figures to fit the local situation, the maintenance officers in any institution should be able with reasonable accuracy to estimate in advance the total annual cost of lighting and maintenance

for new construction if they know the following: the total wattage of the lamps in the building; the estimated average number of hours the lamps are to be used annually, including cleaning time; the cost per kilowatt hour charged for the electric current; the time schedule for the frequency of cleaning and replacing lamps; the wage rates and the number of hours that the cleaning and maintenance and replacement of lamps can be expected to take; and the estimated annual cost of the repairs and replacement.

It is suggested that such an estimate be made before, rather than after, plans for a new library building are accepted and bids are requested. Two considerations should be kept in mind.

1. Is the institution ready and able to face the costs involved in the lighting proposed?

2. False economy in lighting can be disastrous, and library lighting is so important that its quality must not be neglected.

CHAPTER II

ANSWERS TO QUESTIONS AND COMMENTS BY CONSULTANTS

The consultants, who were selected with the assistance of the advisory committee, represent diverse points of view on library lighting. Arrangements were made to consult 55 individuals—by letter or in person—involved directly or indirectly with library construction or library use. Many of them answered a series of questions about lighting. Nine different sets of questions were used. Each consultant received a letter explaining the study and a questionnaire which applied to his special area of interest or competence. A large percentage of those approached provided thoughtful and useful replies. More than a dozen personal interviews were arranged, and twelve group meetings with three or more persons were held. Pertinent material in print or manuscript form was examined. Appendix A gives the names and occupations of those contributing; Appendix B presents a brief list of useful articles and books.

A fairly detailed record of the information received follows. A section is devoted to each of the eight groups consulted. For each of the groups, general statements on lighting are recorded first. These are followed by the specific questions that apply to the group, with the answers to each question by the individuals who cooperated. The answers are often presented in a condensed form and in some cases are simply summarized, but care has been taken to include all points of view. The advisory committee has seen all of the reports in their original form.

Architects

Architects generally have more influence on library lighting installations than any of the other groups consulted, for theirs is the primary responsibility. They are appointed by academic institutions to prepare plans, working drawings, and specifications for new library buildings, for additions to existing buildings, and for the rehabilitation of old buildings. They are chosen because they are believed to be competent members of their profession, capable of planning a satisfactory building which fulfills the institution's program and presumably one which can be constructed for an agreed-upon sum of money. If architects are not lighting specialists and do not have experts in this field on their staffs, they employ engineers to prepare under their direction the working drawings and specifications for the lighting and other electrical installations. They take

particular interest in the lighting because of its effect on the aesthetic results of a building as a whole. Functionally, the lighting is an important factor affecting the work of the library staff and readers who use the building. The architects should be aware also of the special needs of persons with defective vision.

The writer's experience indicates that architects occasionally delegate their responsibility for the selection of the types of fixtures used, their placement, and the quality of lighting to illuminating engineers or to representatives of the institution—that is, librarians, building planning committees, or financial officers; architects sometimes approve specifications prepared by persons who are not sufficiently aware of the quality requirements of lighting or of the aesthetic results, to say nothing of its costs. The architects chosen as consultants for this study were men of competence and wide experience in library planning. They were selected to represent different states or areas of the country—New England, New York, the South, the Middle West, and the Far West.

General Statements

Walter Netsch, of the Chicago office of Skidmore, Owings, and Merrill, wrote in some detail:

> Appropriateness, quality, efficiency, and maintenance are the factors for consideration. We should not be trapped by the absolutes that have rigidified themselves around library lighting design. The librarian, lighting engineer, architect, and the fixture manufacturer have all become captives of these absolutes. Each has his own vested interest and is seldom capable or willing to approach the problem with an open mind or with the spirit of a fresh approach.
>
> The most serious problems facing lighting design today are escalation in lighting intensity, deterioration of the quality of lighting, and rational consideration of initial and operating costs related to the goals to be achieved. A major factor in each of these is the limitations of the types of lamps and fixtures themselves.
>
> Everyone recognizes that a certain light level range is necessary to perform certain tasks involving visual contact. What has happened, however, is that the range has become absolute with no variance. Considerations of quality, comfort, reflectance, contrast, texture, and general environmental aesthetics are seldom weighed. Basic light levels should be established for certain task areas (reader areas, stacks and offices), but should not be so firm or inflexible that they cannot be varied depending on other decisions of quality, reflectances, materials, texture, and appropriateness.
>
> The quality of lighting has suffered the most, and along with it the environment. Technological limitations combined with the escalation in intensity, the most efficient fixture, and cost considerations have taken a tremendous toll in the quality of the lighting and the environment. The

result, most often, has been an antiseptic movement to brightness and efficiency.

Keeping the design goals in perspective, with the initial and the operating costs, is one of the most difficult aspects of lighting design. It is almost impossible to achieve an appropriate environment and maintain low watts per square foot, low brightness, high footcandle levels, a high efficiency fixture, and low initial and maintained costs.

We have found the only effective tool in achieving the basic design goals of the building and a realistic evaluation of light levels, quality of light, initial cost control, and maintenance is to build a mock-up, duplicating the crucial conditions in the building and actually installing and investigating several lighting schemes. Each scheme must be evaluated in conjunction with the color, texture, reflectivity, and maintenance characteristics of the material to be used in the building and furnishings. A decision on any one can materially affect the results. An actual lighting system installed in a mock-up quickly demonstrates the obvious limitations or potential of a basic scheme. The visual qualities of the fixture, light level, and materials composing the total environment can be quickly perceived and evaluated. It is essential that the mock-up be used prior to working drawings. It becomes an excellent tool for refinements during working drawings and for use during the selection of the interior furnishings.

Pietro Belluschi's attitude toward the intensity of lighting, which is its most controversial problem, is recorded in the following paragraphs.

Like most architects, I am rather co ed by the many conflicting claims advanced by engineers and power · panies on the need for greater and greater lighting intensity in almos ery situation. In my younger days I designed a great many libraries on the West Coast. In some of the larger ones, with the high ceilings called for by traditional design, the problem of lighting proved to be well-nigh insoluble. Table lights were cumbersome and inefficient, and high general illumination difficult to justify on technical and financial grounds. I remember at that time discussing the question of light intensity with a prominent eye doctor who was also a noted physiologist; he was convinced that any intensity above 25 footcandles was harmful. (Some of the older library rooms had only 2 or 3 footcandles.)

I have been design consultant for 2 power companies. In one the space occupied by the office workers has an average intensity of 600 footcandles; this company is trying to set an example for other commercial spaces which would then need more electric power. The other, which is erecting a new 30-story office building, is planning for 300 footcandle intensity. The claim, of course, is that on a clear day a man in the street is subjected to 1,000 footcandles, which is assumed to be a natural level. Obviously the key to the acceptance of any particular intensity is its evenness; eye fatigue comes from contrast. The eye becomes adjusted to

almost any level provided the adjustment does not have to be protracted or continuous. That is why light tone finish on tables has been advocated and dark corners in a room eliminated as much as possible. So quality, not quantity, of light is the test.

When technical and cost considerations are brought to bear, I feel that a comparatively low intensity, 50 to 100 footcandles, is acceptable provided it is evenly distributed.

Kenneth DeMay, of the Watertown, Massachusetts, firm of Sasaki, Dawson, DeMay Associates, Inc., wrote as follows:

> This particular subject is extremely provocative and complex, as you undoubtedly realize. My own feelings are that the high levels of illumination have been foisted upon architects and owners by electrical manufacturers who are interested in selling more and more fixtures regardless of common sense: very much like the ludicrous situation in Detroit with the automobile industry.

Eugene J. Mackey, of the St. Louis firm of Murphy and Mackey, wrote very briefly, hastily and by hand a few days before his untimely death:

> I believe that lighting leaves so much to be desired. The subject of overlighting is something like overkill as far as emotional content or feeling is concerned.

Question

What aspects of lighting and what requirements and specifications for lighting should be included in a program submitted to the architect by an institution that is planning library construction?

Answers

1. Evenness and lack of contrast are essential.

2. The lighting part of the program should not be submitted as a finalized statement, and the library should leave to the architect the task of putting the requirements together as parts of a jigsaw puzzle; the architect should be part of the program development team and should, of course, learn from the librarian and library consultant as much as he can about the needs of the occupants.

3. The program should provide a general statement on the visual tasks to be performed in various areas of the library, particularly areas where unusual, difficult, or prolonged visual tasks are involved. It should include information on the visual environment or effect desired in the building. Attention should be called to any special lighting requirements. As a guide to the architect, installations of good and bad lighting may be cited with the suggestion that the architect should visit them.

4. Any information, opinions, requirements, and desires regarding lighting would be helpful to the architect.

5. It would be extremely helpful if a program submitted to the architect would indicate footcandles required in various spaces or any criteria which the institution feels is a necessity for the finished job.

Question

Should the program specify types of fixtures, lighting patterns, and intensities for different parts of the library, such as reading areas, stacks, offices, lobbies, corridors; and if so, what are your suggestions in this connection?

Summary of Replies

Three architects said the program should not be specific in its requirements for fixtures, lighting patterns, and intensities, but a fourth added that it might suggest intensities for different parts of the library, always emphasizing that quality is more important than quantity of light. The fifth proposed that the optimum intensities of light in any area of the library will vary with the function of the area and the services provided and that an important part of the total solution is in the light levels assigned to corridors and other parts of the library that serve as transitional spaces between the areas of different light intensities. He added that the selection of fixtures and the design of lighting patterns are integral parts of the building design and cannot be considered separately.

It seems evident that architects were not primarily interested in intensity and felt that they wanted a rather free hand in selecting the fixtures and lighting patterns.

Question

Do you have specific views on the desirable minimum and maximum light intensities, prevention of glare, maximum brightness ratio of visual environment, the use of windows as a light source, the applicability of polarized lighting, and other aspects of library lighting? Do you have any recommendations for the desirable footcandles for various types of areas (reading rooms, book stacks, offices, lobbies, corridors, and so forth)?

Answers

1. There are many logical arguments for the elimination of windows, but I am generally against this. The inclusion of windows is a psychological intangible but very important; yet windows alone will not do the job. Natural light should be reinforced by artificial light. I have no firsthand experience with polarized lighting. I would keep footcandle level low, say at 75, but consistent throughout the building.

2. Concern for the visual environment is an integral part of the total design

of the library. It includes control or prevention of glare through the use of non-reflecting wall and ceiling materials, the choice of colors, and so forth. The solution of the problem of desirable light intensity for various types of areas in the library does not necessarily lie in the number of footcandles. Each area should meet the criteria for the quality of light desired for the particular function. The specific intensity of each given area should be considered in relation to the adjacent areas.

The use of windows as a primary light source is not practical. The library must serve during the various times of day when outside light varies in intensity and from day-to-day throughout the year when the orientation and weather conditions affect the light entering a building. At the same time, this office does not recommend a windowless building as a design solution. Windows are important for psychological comfort and should be located in a manner that permits those who read for long periods of time to utilize the windows as a change of experience. Looking into the distance is one means of providing rest for the eyes when they become strained from intensive reading. The library should be designed with artificial light necessary for the optimum level of intensity for reading comfort and with a minimum contrast between the reading surface and surrounding surfaces. It is assumed that the architect will locate windows in such a way that they do not permit damage to the books.

3. We do not have specific recommendations as to maximum and minimum intensities for lighting as such. There are too many factors to be kept in mind if satisfactory lighting in a particular case is to be achieved. These would include the following: the particular seeing task; the visual environment; accustomed lighting; duration of effort; quality of light; initial cost and maintenance, including heat effects; and intensity to be maintained or life period of a particular light source.

Windows are still a good, as well as accustomed, source of light, particularly from the better directions such as from the northwest to east. In using natural light, consideration must be given to requirements of artificial light in adjacent areas in regard to relative intensity, brightness ratio, and contrast. Skylights and clerestory light are often a problem in relation to lighting of adjacent areas as well as design of continuing artificial lighting in periods after daylight.

Polarized light would seem to have a very limited and specialized application. Not only must the work be kept in a specific relation to the light source, but only a small fraction of the total available light is utilized for the task. If the desire is to limit glare or spectral reflection, it would seem better to accomplish this by proper diffusion of lighting over the task.

With reference to footcandle levels, as noted before, we do not believe that is a major criterion of good lighting. One hundred footcandles on the page from a direct down light may be almost impossible to read by, whereas the same wattage from an indirect source, though low in footcandles, may be a pleasant and adequate light. If the amount of light is assumed adequate, it is the quality that is important, not the intensity. Fixtures that improve the quality of light usually require more wattage for the same intensity at the reading level. On the other hand, the level of intensity may well be lower with quality lighting. The eye itself can adjust.

In our libraries the average of 50 footcandles maintained may be a criterion of reading areas, but it may vary from 30 to 60 in one place or another in the building. The variable is to accommodate the needs and desires of different people whose tastes or requirements are not all alike.

4. I do not have specific views on desirable minimum light intensities. Of course, glare should be prevented, and this is usually accomplished by reducing the brightness ratio and by avoiding contrast in light values.

One can write a great deal about the use of windows as a light source. Maybe it is sufficient to say that the penetration of sunlight should be avoided and that sky brightness is a source of glare. I do not have any recommendations as to the desirable footcandle levels for the various areas. However, we do consult illuminating engineers in this respect, and it seems that opinions vary and change from time to time.

5. Although IES standards are controversial, we do not know of any other guide, and the latest IES standards range from 30 footcandles to 70 footcandles for libraries, a range which doesn't appear to cause overbrightness. Also, IES guides are about the only ones available on glare control, brightness ratio, and similar lighting characteristics. As you know, we are not fully satisfied with IES standards as they appear to be written by people in the manufacturing industry, and we think their only interest is in selling more fixtures. At the moment, however, no sources exist other than the illuminating specialists who during the process of design have to place lighting in such locations as to provide the best aesthetics and to hide, insofar as possible, the light sources. There is some merit in natural light through windows to conserve power if the lights are turned off during the daylight hours; however, the design for lighting cannot take windows into account since the libraries must be used on cloudy days and at night.

It is evident that architects have no fixed opinions about light intensity. They are more interested in quality. They believe in windows but realize that light from them must be controlled and does not solve the lighting problem.

Question

Do you as an architect prepare lighting specifications for library buildings you design? For instance, do you call in an illuminating engineer whom you employ for the purpose, or do you expect specialists on your staff to prepare the drawings and specifications for library lighting installations? Who makes the final recommendations that you present to the library authorities?

Summary of Replies

One architect states that he calls on his electrical engineers and specialists to prepare specifications on lighting. The others make similar reports, but add that after conferences in which the problems are analyzed

and conclusions are reached, the architect takes the final recommendations to the client. One architect notes that occasionally, with the backing of the client, he will have made a full-size mock-up of a typical space where different fixtures are tried.

In general, the architects believe that the program should not be specific in its requirements (at least until the architect has had an opportunity to talk over the problems involved with his client) for costs, intensities for different parts of the library, types of fixtures, and lighting patterns. They may call in the illuminating engineers to help on drawings and specifications, but they want to hold the final decision in their own hands, and feel that they should be the ones to deal directly with their clients.

Question

What role does the lighting installation play in the design of the aesthetic aspects of the building?

Answers

1. We are learning more and more about the architectural implication of lighting. A designer should strive more for good visibility and less for dramatic effect, although the two need not be mutually exclusive.

2. Lighting is a building material the same as brick, glass, mortar, and so forth. It cannot be separated from the rest of the building in the design of aesthetic effects. A poorly conceived relation among lighting patterns and ceilings is not only displeasing aesthetically but functionally inadequate.

3. We consider lighting, together with color, the major elements of interior design and work them out together. We try to avoid a uniform intensity of light throughout a building. We understand that, physiologically, proper variation in light intensity results in reduced eye strain or fatigue. Eyes have a chance to rest or relax, even momentarily, on glancing around a room.

4. Lighting plays an important role in the aesthetic aspects of any building, not only of library buildings.

5. The lighting installation plays a major role in the design of the aesthetic aspects of a library building. If we were not controlled by budgets, we would prefer an overall, evenly lighted ceiling with the sources of light always hidden, diffused and polarized.

Question

What priorities do you assign to the following aspects of a library lighting installation: aesthetics, initial costs, operating cost, function and quality?

Answers

1. Function and quality; operating costs; aesthetics; initial costs—although I have found that initial cost is always the first determinant even though it should not be.

2. Priorities cannot be assigned in an arbitrary manner. A properly designed space considers all of these factors without establishing dangerous priorities at the expense of the total library.

3. Function and quality; aesthetics; operating costs; initial cost.

4. Quality and function should be number one. Costs, both initial and operating, number two; and aesthetics, number three. If the installation is good looking, but is costly and unworkable, then the owner does not think it is good looking.

5. Priorities are too often these: first, initial cost; then, aesthetics, function, quality, and operating cost.

Question

What emphasis should be given to other points that should be taken into account, such as flexibility, individual lights in carrels and elsewhere, table and floor lamps, treatment of special rooms, and so forth?

Answers

1. If quality is good and even, flexibility is enhanced. Individual lamps are of psychological value only, but I would not minimize their value.

2. High priority should be given to flexibility which may or may not increase capital investment, but could prove to be the best means of effecting economy in library construction.

3. In the matter of flexibility, individual lights in carrels are preferred by the users, but in these days, perhaps always, they are too easy to take home. It comes down to providing adequate fixed light, plus an outlet for the reader to plug in his own lamp. Lighting is an essential element in the design of special rooms.

4. Each situation is different and may require a different treatment.

5. Most flexibility can, of course, be achieved with an overall lighted ceiling, but the cost is sometimes prohibitive when budgets are low.

Question

Can you cite instances from your own experience where there seems to have been a conflict among aesthetics, function, and cost considerations? How were such conflicts resolved?

Summary of Replies

The architects, as one might expect, found this a difficult question to answer. One reported that conflict is a constant in an architect's life, and

there are no firm guidelines other than common sense, taste, and experience. Another suggested that visits to pertinent installations, development of models and mock-ups, and listening to the views of consultants helped. A third said that there should be no conflict between aesthetics and function; cost is another question. Conflicts are usually solved by imagination and compromise. A fourth had no conflicts on which to report, and a fifth said the cost consideration prevents proper function and results in inadequate light, often leading to costly attempts that are made later on to improve the wiring and lighting fixtures.

Illuminating Engineers and Physicists

Letters were sent to seven illuminating engineers and physicists, each of whom is experienced in the field of library lighting or is the author of writings demonstrating his interest in the topic. One failed to answer, although written to three times. A second sent copies of his reports on the subject, excerpts from which are quoted later, and a third arranged to obtain helpful replies from his colleagues. A fourth expressed interest, but said that his involvement in the design of library lighting had been exercised only in small, specialized facilities where the library function was secondary to other functions; consequently, he could draw upon no reservoir of information on the subject.

A fifth wrote briefly that the whole area of the visual environment is necessarily a vital part of library planning and that endlessly increasing illumination levels are not the answer: the kind of light provided and its precise control are more germane to the problem. He went on to say that he worked closely with the architect on aesthetic values, but took full responsibility for the lighting design in all its "specifics." The sixth consultant answered the questions in detail; the seventh preferred not to answer in writing but made himself available for personal interviews. He read the draft of this report and corrected a number of technical errors in it. He has confirmed the figures used in the Table on page 90 on the operating and maintenance costs of two imaginary libraries of 100,000 gross square feet, which have variations in lighting intensity. He is now helping in the planning of a new library building with the variations in the lighting proposed in Chapter IV. He does not agree with all the writer's conclusions and recommendations, but says that they are not unreasonable and should result in a satisfactory library if the quality of lighting is good.

In addition to letters and replies mentioned in the preceding paragraphs, the writer has made use of the Illuminating Engineering Society's *Lighting Handbook*, fourth edition. He has met regularly for over 18 months with the Society's subcommittee which is preparing the section on library lighting for the fifth edition.

He has found printed reports on library lighting very useful, among them one by H.L. Logan, vice president in charge of research for the

Holophane Company. Part of this report, entitled "Lighting and Well-Being," published in the May-June 1961 issue of *Catholic Property Administration,* can be summarized as follows: The apparent scientific support for diffusion lighting techniques with their reduction in contrasts, their suppression of potentially revealable information, and their creation of sameness in architectural spaces, plus the mandatory use of these techniques in various legal jurisdictions where they have been frozen into law—all this has reached the point where corrective measures are in order. This correction can best come from well informed users. Mr. Logan states that carried to its ultimate the scientific approach would produce a functional but highly bland environment which would not be a desirable end. His proposal for a satisfactory guide to quality lighting follows:

1. Plan for sufficient lighting properly controlled to convey all visual information people need to work effectively at their tasks and be fully alert to their surroundings.

2. Work with familiar rather than strange elements in illumination and color to avoid confusion or emotional rejection.

3. Never forget the factor of human appearance. People are always dealt with, not eyes or tasks alone.

4. Give all elements in the lighted space a realistic appearance without flattening them out with lighting or distorting them unfavorably with color.

5. Plan for variety as against monotony. All the details of an environment should be distinctly revealed and not lost in uniformity.

6. Hold light levels and color contrasts within the limits of reasonable adaptation.

The article by the Light Sources Committee of the Illuminating Engineering Society in the May 1967 issue of *Illuminating Engineering,* entitled "Choosing Light Sources for General Lighting," provides useful technical information on lumen output, efficacy, life expectancy, color acceptability, degree of light control, and the maintenance of lumen output for 9 types of lamps now in use.

The question of advantages and disadvantages of polarized light has been the subject of considerable discussion in recent years. Dr. Blackwell, professor and director of the Institute for Research in Vision, Ohio State University, has been an advocate of polarized lighting, while C.L. Crouch and J.E. Kaufman have written in *Illuminating Engineering* that in many parts of a library it is ineffective; it is useful primarily when the working surface is flat. The average reader, however, spends much of his time reading with the book or papers raised at one end.

In *Lighting and Electrical Design* for November 1967, Gene G. Rae, a vice president of the Holophane Company, in an article entitled "What Lighting Will Be Like in the 1980's," predicts that the standard intensity of office lighting in the late 1980's will be 200 footcandles. He adds that

there seems to be very little possibility of increasing the effectiveness of the incandescent lamp, although increases of lighting efficacy can be achieved. He adds that while the incandescent lamp continues to have many useful applications and will be with us for the next 20 years, we must look to other sources and methods of light generation to come closer to the goal of optimum transfer of electrical energy into light. Fluorescent light has been improved so much in efficiency, lumen maintenance, life, and reduced costs that the user now receives 40 times as many lumen hours per dollar as when electric lamps were first introduced. He says that the fluorescent light will continue to be the predominant source for commercial structures for many years to come, but he believes that the mercury lamp has a most promising future and that we can expect the usual number of exotic but impractical light sources. He saw no future for the quartz-iodine lamp, the panel fluorescent, the electro-luminescent plate, sodium-vapor—except to augment mercury-vapor lamps—or various striped or sea-green fluorescent lamps, although others disagree on these points.

Dr. William M.C. Lam, an engineer who has specialized in lighting problems, states that the cost of increasing lighting power requirements from 3 watts to 6 watts per square foot of area is estimated at $1.00 for the initial cost, and $.32 per square foot on the operating costs for energy for a year. He adds that some additional cost of maintenance of the larger air conditioning systems could also be attributed to the higher lighting power requirements. He criticizes lighting codes and intensities which are selected for administrative ease rather than accuracy, stating that they continue to rise in response to industry pressures and have already reached levels that force designers with budget limitations to ignore quality in favor of quantity, a factor which results in poorer visual environments. He adds that the purpose of codes should be to insure health and safety, but that the code requirements, which long ago moved beyond that purpose, interfere with value decisions.

Dr. Lam compares the problems of lighting with those of acoustics, stating that the law of diminishing returns applies in each case and that, as is true in lighting, the quantity of sound above minimum hearing levels is not as important as its quality. The volume necessary for communication is affected by background competition: one needs to speak more loudly in a factory than in a church, and our reaction to sound, like our reaction to light, is always in terms of its relevance to its environment.

Dr. Lam also says this:

1. We see well over a tremendous range of light levels.
2. We see by the balance of light more than by the quantity.
3. Once 10 to 15 footcandles have been achieved, task visibility can be improved far more easily through quality changes than by adding quantity.
4. Apparent brightness is determined by brightness relationships.

5. We look at tasks only a small part of the time but react to the environment all of the time.

6. Whether our response to the environment is to be favorable or unfavorable cannot be forecast or explained by numbers but results from the exact design of everything in relation to what we want to see.

Dr. Lam suggests that in many cases a mock-up would be useful. A mock-up must be paid for only once, but the extra kilowatts must be paid for every year of building use, and the responsibility for providing the best educational value for the money spent is shared by all concerned.

Printed sources might also be quoted, but these would necessarily increase the length of this report and probably only complicate it. At best, it is evident that there is far from complete agreement on several major points relating to lighting. Among these questions are those which seek the determination of the most desirable installation for different types of work (and in this regard whether overall general lighting is the best solution), and those which deal with the diffusion of light, the definition of quality, and the relationship between quality and quantity of light.

One of the consultants wrote in regard to the agent responsible for specifying lighting, "I can only say that it doesn't really matter as long as he is competent. At present very few institutions, architects, or electrical engineers are competent in this area or are likely to become competent in the near future. The only way that good performance specifications can be derived is through a program written by a nonindustry-related group which considers all of the relative aspects."

Specific questions with answers (and comments in some cases) follow:

Question

What requirements and specifications for lighting should be included in the program submitted to the architect by an institution that is planning library construction? Should the architect provide additional information when he presents the lighting problem to an illuminating engineer?

Answers

1. An institution planning a library should present its program with specific information on the types of areas to be included in the library. Representatives of the institution, the architect, and the illuminating engineer should meet together to plan the lighting installation. The initial meeting should include discussion of the type of lighting in each area, the amount of lighting in each area, and other general factors concerning the lighting installation. The initial proposal would then be made by the illuminating engineer subject to further review by all parties prior to finalization of the lighting specifications.

2. Specifications and requirements for lighting to be included in the

institution's summation to an architect planning library construction should follow the current recommended practice published by the Illuminating Engineering Society. These recommendations encompass two areas—quantity and quality. The figures for the quantity recommendations should be the minimum on the task at any time: that is, with the luminaires in dirtiest condition and the lamps at the end of useful life—the day before cleaning and lamp changes. The quantity of illumination is based on the task without regard for the plane in which the task is located; if an observed surface is vertical, such as the binding area where the title is placed on the back of a book, the delivered illumination must be read in a vertical position which is the plane at which the title is observed. Stack areas and card file areas are excellent examples of cases where vertical illumination components are of far greater significance than horizontal illumination. The quality aspects are generally expressed as luminance ratios. To achieve comfortable balance it is desirable to limit luminance ratios to the following values:

One to one-third between seeing task and adjacent surroundings.

One to one-tenth between task and more remote darker surfaces.

One to ten between task and more remote lighter surfaces.

Twenty to one between luminaires or fenestration and surfaces adjacent to them.

Forty to one anywhere within the normal field of view.

Any reduction in these ratios will generally produce beneficial results.

3. These criteria immediately impose some rather definite design restrictions on the architect, particularly in the selection of finishes. Application of these criteria to such areas as the stacks presents special difficulties, because the architect does not control the selection of books. If there is low contrast between the color of the binding and the title information stamped on the spine, even the best lighting conditions will not make the title easy to decipher.

The architect should provide complete information to the illuminating engineer as to all finishes to be used along with their relationships, the usual anticipated directions of viewing, and the occupancy locations. Complete plans, elevations, and other pertinent visual information, pointing out any special areas concerned in the environment, should be provided. The provision of such information is not the usual case today.

The program should tell what the space is used for and describe the tasks that are to be performed in it. It should describe the desirable environment for the particular task and should indicate the relationship of the environment to the overall design concept of the building.

Comments

Three quite different points of view are represented in these answers. The first indicates the importance of consultation among the groups involved before definitive lighting specifications are written. The second,

which is not unusual for an illuminating engineer, suggests following the recommended practice of the Illuminating Engineering Society as shown in the latest edition of its *Lighting Handbook*, and the third shows special interest in the environment.

Question

Should the program specify types of fixtures, lighting patterns, and intensities for different parts of the library, such as reading areas, book stacks, offices, lobbies, and corridors?

Answers

1. Specific types of fixtures, lighting patterns, and intensities should not be proposed by the institution at the first meeting. These factors should be discussed at a second meeting after the general information proposed above has already been discussed.

2. The program should primarily specify performance, photometrics, and aesthetics, plus quality level of luminaires, suggesting that the architect or consulting electrical engineer knows equipment, luminaires, and mounting arrangements which will accomplish the criteria decided upon.

3. Do not under any circumstances prescribe equipment or design solutions. The program should specify only performance criteria which should be different for different parts of the library.

Comments

The comments on the preceding Question apply here, showing the three different points of view. The importance of consultation is evident as well as the desirability of specifying performance criteria which will vary in different parts of the building, rather than prescribing specific equipment or design solutions.

Question

Do you have specific views on prevention of glare, maximum brightness ratio of visual environment, the applicability of polarized lighting, rheostats, and other aspects of library lighting? How do you handle the question of color? In what cases are special designs justified? Do you have recommendations for the desirable intensity levels for various types of areas?

Answers

1. Glare is one of the most important subjects yet it is rarely specified, or even discussed, in most lighting installations. It is, of course, closely akin to the maximum brightness ratio of the visual environment. The subject of polarized lighting is synonymous with the elimination of reflected glare, but it cannot be considered to be the cure-all for an illumination system. Rheostats are not an

essential part of library lighting since they are more involved with lighting systems in conference rooms or similar areas where lighting levels need to be changed frequently. The function of color is involved with the final environment and the illuminating engineer only needs to realize that his final selection of light source must be in harmony with the final selection of colors used. Special designs of lighting fixtures are rarely justified. A multitude of lighting systems are commercially available to meet all needs of an installation without creation of special lighting systems. The present lighting recommendations made by IES are adequate for all general situations. Deviations from these basic recommendations should only be made after thorough discussion between the institution and the illuminating engineer or architect proposing them.

2. Prevention of high brightness luminance differences (glare, which causes annoyance, discomfort, losses in visual performance and visibility) is a complicated task. Quality criteria tend to minimize the effects of luminance differences. They also apply to the discomfort occasioned by the reflected brightness. The prevention of uncomfortable visual situations is governed primarily by three areas of concern: the architectural constraints in the space and the placement of luminaires; the economics of the situation; and the availability of proper shielding media which produce satisfactory brightness relationships. Generally, if brightness can be controlled, if desired illumination levels can be achieved, an entirely luminous area, such as can be effected by an indirect system, will solve many of the problems. The question of color is handled generally by the architect. The major choice in fluorescent lighting is cool white if sales trends are any criterion. It has high efficacy, reducing the load of lighting and air conditioning. Recommendations relative to desirable intensities are based on current approved practice issued by IES. They are founded on basic vision research and have validity and backing for the healthy eyes of a 20-year-old. Further research is being conducted on requirements for older and impaired eyes and may well bring further increases in levels of illumination required.

3. Performance criteria of the types suggested allow for weighted judgments of the various aspects that make up good lighting, including glare, polarization, and so forth.

Question

Do you as an illuminating engineer prepare lighting specifications for libraries you illuminate? Do you simply follow the architect's recommendations? Who should make the final recommendations that are presented to the library authorities?

Answers

1. Again I refer to an initial meeting among representatives of the institution, the architect, and an illuminating engineer after which a second meeting is held to review recommendations made by an illuminating engineer prior to finalization of specifications.

2. The responsibility for recommending lighting for most spaces belongs to the architect and the consulting illuminating engineer. To that end we choose to

work with these principals in development of specifications for library illumination. In those cases where no architect or engineer is involved, we recommend existing in-line equipment, attempting to produce as comfortable an environment as possible in order to meet the criteria already outlined and with the job in mind. We generally follow the architect's recommendations since his is the prime responsibility to his client. If a glaring error occurs or if our experience shows his approach is wrong or questionable, we usually attempt to draw this to his attention. The architect who has control of the building design should make the final recommendations presented to the library authorities. It is his responsibility to prepare and study an economic, pleasing, effective design and to incorporate all principles for good vision into his design and specifications.

3. When possible I establish criteria based on discussions of the use of the space with architects and users. Very few electrical engineers have sufficient knowledge of performance criteria to make recommendations.

Question

What role should the library lighting installation play in the aesthetic aspects of a library building? Is it advantageous for you to work with an interior designer on illumination design?

Answers

1. An interior designer or such member of the architect's staff should be involved in all decisions.

2. Lighting should never call attention to itself in any building design. Lighting is there only for the purpose of making the space utilization effective. It should direct attention to the seeing task. It should enable the task to be done efficiently, economically, and effectively. It should also help create atmosphere and delineate attractiveness. It is always helpful to all principals in any building design to coordinate all phases of the design. This cooperation includes as a leader the architect, the consulting engineer, the client, the principal associated trades, and the interior designer, all of whom should work as a team if an efficient, economic system is to evolve.

3. The luminous environments produced by lighting installations and their relationship with the building and furnishings constitute most of the aesthetic aspects of any building. All elements, including interior design, as well as structural, mechanical and other components, must be coordinated for a good design.

Comments

It is evident from these answers that lighting is considered by all concerned as an important part of the aesthetic aspects of a library building, although there may be some disagreement as to whether or not lighting should be obtrusive.

Question

How much is the cost of lighting intensity and its operation affected by changes in the quality and intensity of light? What emphasis should be given to the operating cost of the lighting installation?

Answers

1. The aspect of cost should be mentioned as an item of consideration at the first meeting and should be fully outlined by the illuminating engineer at the second meeting.

2. Each structure has its own cost due to its individuality. If long-life fluorescent or high-pressure gaseous discharge sources are used, their inherent efficacy reduces the operating cost. If IES recommendations as to quality and quantity are used, the operating costs are minimal compared to the benefits and utility of the structure. It becomes very difficult to place a dollar value on the worth of a library in relation to operating costs.

3. It is much less expensive to achieve good working environments in libraries by providing a high quality lighting installation than by increasing intensity. In studying costs we plot initial and operating costs.

Comments

All three answers indicated interest in costs, but with different emphases. The first suggested that costs should always be kept in mind; the second, that it is difficult to determine a specific dollar value; and the third, that the emphasis should be on quality rather than intensity.

Question

Is your work complicated and are the costs affected if lighting intensities are to vary in different parts of the building, for instance, workrooms, offices, faculty studies, manuscript and archives rooms, and a few reading rooms that may require higher intensities than the majority of the reading areas and the book stacks?

Answers

1. IES practice recommends different levels of illumination for different parts of the building. The illuminating engineer is expected to work out the variables in intensity. I see no reason why changes in illumination levels for various parts of the building should be considered detrimental or require added costs for the final lighting system. In fact, consideration of these variables is the standard practice. It saves the user both installation and operating costs. Such consideration is not really costly and ends up making the illuminating engineer earn his fee.

2. Our work contribution is not generally complicated when intensities are varied according to task. However, the cost of equipment due to variations in

quantity, circuitry, and operating expense may be greatly affected. As the illumination goes up so the costs of providing and operating that equipment rise.

3. My work is made easier rather than complicated if lighting intensities and types of lighting vary in different parts of the building in relation to the use of those spaces, room proportions, and so forth. Cost is substantially lower if lighting intensities, type of distribution, and so forth, are appropriate for the task, rather than uniform throughout the building.

Comments

There seems to be no question about the practicability of using different intensities for different areas within the building.

Question

What effect does the provision of high lighting intensity have on the cost of installation and the operation of air conditioning?

Answers

1. As illumination levels increase, the cost of installation definitely increases as well, and the same holds true for the cost of air conditioning systems. It is the job of the illuminating engineer to justify all costs associated with the lighting system recommendations.

2. For each watt of power consumed by a lamp, 3.4 British thermal units per hour are generated. Therefore, the higher the wattage loading in an area, the greater the requirement for additional air conditioning capacity.

3. A substantial part or, in some cases, most of the cost of installation of air conditioning should be charged to provision of the overall lighting intensity.

Comments

Note that in all cases it is made clear that higher intensities than are necessary will add to the costs of installation, maintenance and operation, and air conditioning.

Question

What should be the division of responsibility among architects, illuminating engineers, and construction engineers in connection with the decisions in regard to intensity, aesthetics, quality, function, and cost?

Answers

1. The illuminating engineer must be the one to make the recommendations; otherwise, there is no need for his involvement. The institution as the user and the architect as the prime coordinating force should, of course, have veto power or the possibility to suggest alternate systems for consideration by the illuminating engineer. The other parties involved, especially those concerned with the aesthetics

of the installation, must have a strong voice in determining what system is utilized, or the final environment will not be considered adequate by everyone involved.

2. The architect, reflecting the client's desires, is the captain of the job. His direction should be based on established, proven IES standards. Maybe he doesn't believe in these standards. However, the results obtained by following these standards stand as proof of their effectiveness.

3. The architect should be responsible for all aspects of lighting as an integral and inseparable part of the environment he is creating. He should enlist the aid of the most competent consultants to help him meet this responsibility. In my opinion it is better to have no criteria than to have the wrong type of criteria primarily based on quantity of low or high intensity when so many other things are much more important. Until the right kind of performance specifications have been developed, I think it would be far better for library committees to search for good examples in libraries and other types of buildings and challenge the architects to do as well. Allocate funds for building mock-ups of promising proposals. Small investments in this form can pay great dividends initially as well as in the long run.

Comments

There is decided disagreement in these answers which goes back to a disagreement on whether quality of lighting can best be obtained by following IES standards or in other ways.

Other Engineers and Consultants in Building Planning

Architects take the responsibility for planning library buildings. They assign the major part of the lighting installations to electrical engineers. Architects may also call in other technical specialists who are involved in one way or another in lighting. Seven letters accompanied by questions were sent out to representatives of this latter group. The six persons who answered included a conservation expert, a building contractor, a member of a planning services firm, a consulting engineer and architect, a cost estimator and cost control consultant, and a consulting engineer. Five of the six made general comments; three answered most of the questions. The general comments follow:

The report of the museum conservation expert can be summarized in this way: Library lighting interests us because it presents the same problems encountered in museums: human health and comfort vs. the collections. We keep in touch with those who are studying the effects of light on museum materials. The rate of deterioration depends on light intensities and the duration of exposure, as well as on wave lengths. All materials suffer photo-chemical damage in various ways, including not only fading of colors but also embrittlement of paper, fabric, leather, and organic adhesives. A satisfactory correlation of light levels seems impossible. We

must accept some slow deterioration. To limit light to 10 or 20 or 25 footcandles may be an academic choice since the damage increases with the intensity. Library material can be divided into three broad categories, one of which is the frequently consulted working collection that might be considered expendable. Light levels for this material should follow the recommendations of physicians and ophthalmologists. A second category is open less often and would be exposed to light energy for very limited times. It could be argued that the high light level for limited periods is not highly destructive. The third category is the rare book collection which deserves the most careful treatment. There are two special considerations here: Rare books are often displayed in lighted exhibit cases; and some books may be on permanent exhibit in floor or wall cases. Certainly a reduced light level seems advisable in these situations which are analogous to a museum gallery where the 15 to 20 footcandle level is recommended.

The representative of the contractor wrote: "Our company has had the responsibility as builder on a number of library projects. Two might be mentioned where the lighting systems used were a matter of great concern to the owner, consultants, and designers. For each of them, 10 percent of the total cost of the structure was for the fixtures and other related electrical items."

A planning and managing consultant said: "I serve as a bridge between the architect and the client. It is not appropriate for the librarian to specify a particular kind of fixture or to mandate particular lighting systems, levels of illumination in footcandles, and so forth. Obviously, there is nothing wrong with librarians putting such information as they have on the subject at the architect's disposal. Our cost estimators note that electrical work for lighting tends to run between 10 and 17 percent of total library costs or from $3.50 to $5.50 per square foot. The sums include not only lighting but also alarm systems, intercommunication, telephone conduits, and so forth. Of these sums lighting is likely to represent from $2.50 to $3.50 per square foot if fluorescent lighting is used, with 75 footcandles initial level or 50 footcandles maintained. This might be said to be from 7 to 12.5 percent of the total construction costs. If a level of illumination increases to 100 footcandles maintained, the impact on cost will be determined by whether the increase comes from a larger number of fixtures, the size of the fixtures, or the type of fixtures. If it is provided by additional fixtures, circuits, feeding wires, lighting panels, and so forth, it may rise to $6.50 to $9.00 per square foot. To the extent that some other means may be used to increase illumination, the total electrical cost would be between these figures."

Another consultant's report is summarized: Remember that the owner employs an architect, and that he should develop a program which will tell the architect what is needed. Intensity and quality of light in various areas deserve to be spelled out as part of the program. The motivation

of the architect is to produce the finest building he can produce, and the only cost limitation is one that is put on by the owner. The architect employs out of his fee an engineer who generally will handle the electrical work which includes lighting. In most cases the architect specifies what he wants, and the engineer then figures out how to do it. When the plans and specifications are completed they are coordinated by the architect. Contractors are not concerned with what is in the plans and will rarely criticize them because of cost or make suggestions for economy. If there is any scientific solution to lighting problems it should come first from ophthalmologists, psychologists, and reading experts.

Specific questions and the answers given by the engineers follow:

Question

What requirements for lighting should libraries specify in their institution's program statement for the library architect? Should the library program be supplemented by the architect when he, in turn, presents it to the construction or consulting engineer?

Answers

1. The program should require that the architect either employ or consult competent lighting engineers to make recommendations on the best possible lighting to be installed in the various areas of the library. Program writers must not assume the role of the designer. It is better to lead the designers to the problems rather than to tell them what the solutions are. The library statement should always be challenged by the architect to find out if he can conscientiously agree with it. If he does agree, he will not need to suggest changes.

2. It is reasonable for the librarian to specify 30 footcandles at the work surface. So far as quality is concerned, obviously contrast ratios should to some extent be limited, but present standards with regard to interior surface colors are overrated and consideration of the relation of window brightness in the daytime to interior brightness far underrated. The important point is that the lighting consultant should be asked to demonstrate in a quantitative way any instances in which he recommends lighting levels higher than 30 foot candles. If for certain specific difficult tasks, such as reading ancient manuscripts, he can demonstrate such a need, then he should be instructed to deal with these on a local basis.

3. Libraries should specify the lighting intensities required for each area of the library and give a general description of the type of fixtures to be used. In presenting this program to the mechanical or electrical engineer the architect should supplement it only to the extent of relating it to the aesthetic concept he is trying to create.

Question

Should the program specify the type of fixtures to be used, the lighting pattern, and the intensities for different parts of the library, such as reading

rooms, book stacks, offices, lobbies, and corridors? If so, do you have suggestions in this connection?

Answers

1. The program should not specify the type of fixtures or the lighting pattern.

2. The librarian should not specify the type of luminaire.

3. Fifty footcandles are adequate for any reading or close work areas and this can be reduced for circulation and service areas.

Question

Do you have specific views on desirable minimum and maximum light intensities or the prevention of glare, on the maximum allowable brightness ratio of visual environment, on the applicability of polarized lighting, and on other aspects of library lighting that will help to insure its quality? Do you have recommendations for the desirable footcandle levels for areas of the different types mentioned in the preceding question? Or do you simply depend on the architect and the illuminating engineer for the solution of these problems and follow the program submitted to you?

Answers

1. The program writer should not force the lighting engineer or the architect into producing certain light intensities, but he should be able to challenge their proposals. There should be a meeting of minds after the architect has had an opportunity to study the program, and a similar meeting of minds after the program writer has had time to study the lighting scheme and details.

2. My information on polarization comes from a person for whom I have considerable respect who reports that the polarizing medium causes a reduction in the footcandles at the work surface; if the light level is raised to compensate for this loss, the subjective glare reaction is just as bad as that without the polarized diffuser. I think that the environment, the speed of reading, and the retention of what is read will not change as the result of the lighting levels so long as the illumination is between 10 footcandles and something up to 8,000. It is my opinion that enthusiasm, speed, and retention will be enhanced much more by the author than by lighting level.

3. The elimination of glare is most important. It can be done satisfactorily by some method of baffling and does not require covering the light source with a translucent material which diminishes the intensity at an increase in energy cost.

Question

Can you cite instances where there seems to have been a conflict among aesthetics, function, and cost as considerations in connection with lighting or among the various groups involved, the architects, the

construction or consulting engineers, and the institution? How were such conflicts resolved?

Answers

1. I have had experience with conflicts relating to lighting. The way to resolve them is to have a well founded knowledge and the determination to state clearly a reasonable and well informed point of view. Experience is a help. The best engineers are the ones who don't mind learning from librarians or architects or from the men who do the labor in installing their designs. The bad engineer is one with a closed mind, and unfortunately there are some of these.

2. If the budget is exceeded, high cost lighting fixtures may be a fruitful source of savings. It is generally possible to substitute less expensive fixtures without sacrificing intensity or quality.

3. The architect often complains about pressure from his electrical engineer to provide high illumination levels not so much because he is concerned about the level but because of the detrimental effect of the large number of luminaires required on his ceiling plan. It has been my experience that the engineer almost always wins by quoting the IES *Handbook*.

Question

What percentage of the total cost of construction does the lighting installation ordinarily take, and is the cost of the installation the major factor in determining this percentage? What is the effect on cost when light intensities are increased? For instance, how much in terms of percentage might the construction cost be increased if 100 footcandles instead of 70 or even only 30 was provided?

Answers

1. The electrical engineer must estimate the costs involved.

2. Wiring, switching, and fixtures run from 3 to 5 percent of the building costs; an increase from 30 to 100 footcandles may add 60 percent to the total installation cost.

Comment

These answers should be kept in mind in connection with the general comments earlier in this section and with the Table on page 90.

Question

What effect does the problem of high intensity lighting have on the cost of installation and operation of air conditioning systems?

Answer

The cost is increased because of the high wattage used. There are systems which have remote equipment controls that boost the light intensity but do not introduce the heat from this change into the cool areas in the building. High intensity lighting does add to the cost but much of the increase can be avoided by exhausting the heat in summer and using it for heating the building in the winter.

Question

Is your work complicated and are the costs affected if different lighting intensities are required in different parts of the building: for instance, in workrooms, offices, faculty studies, manuscripts and archives rooms, and a few reading rooms where it may be desirable to provide higher intensities than in other reading areas?

Answers

1. Different intensities have been no problem for me.

2. There is no complication in having different lighting intensities in different parts of the building. There would be an economy in the initial cost and in operation due to lower intensities in many areas.

Comments

The writer has found no problem in this connection either in the answers given by the consulting engineers or others. It seems obvious that lighting should be adequate for the work being done in any area. The issue is whether or not the provision of more flexibility necessitates that all areas should be lighted so that they could be used for any activity. There is no evidence that the additional intensity within reasonable bounds will do any harm to the eyes of the user, but it will, of course, cost money.

Question

Is it customary and desirable for a construction or consulting engineer to have an illuminating engineer work with him? What should be the relationship among the architect, illuminating engineer and the construction engineer in connection with decisions regarding intensity, aesthetics, quality, function, and cost?

Answers

1. The ideal situation would include an illuminating engineer with an appreciation of architecture. Architects welcome the use of a skilled illuminating engineer.

2. The bulk of the decisions regarding the building design should be made by the architects. The librarian is paying the bill and has every right to point out

the areas where the architect is planning a building which is not in line with a well functioning library program. The role of all the architect's consultants is only advisory. The only areas in which the consultant can insist are those cases where building codes and safety are involved.

Three more sets of questions were presented to one of the consulting engineers. The questions and his answers follow:

Question

Do you, as an environment engineer, prepare lighting specifications for libraries or do you simply follow the architect's recommendations? Who should make the final recommendations for lighting that are presented to the library authorities?

Answer

I recommend special lighting when it is directly related to the audiovisual components. This would include blackboard lighting, podium lighting, the lighting of projection and control booths, and so forth.

Question

What role should the lighting installation play in the aesthetic aspects of a library building? Is it advantageous for you to work with an interior designer or an illuminating designer?

Answer

Whether or not it is advantageous to work with an interior designer depends entirely on the competence of either the architect or the interior designer.

Question

How much is the cost of lighting intensity and its operation affected by changes in the quality and intensity of lighting? What emphasis should be given to the operating costs of the lighting installation?

Answer

Maintenance costs will be more readily evaluated as architects and engineers increase their use of computer systems in planning buildings. Value judgments will still have to be made, but computer model studies can permit the real effects of factors such as lighting quantity and operating costs to show up in a factual way.

Interior Designers

While many architects plan the interior of libraries that they are designing, some bring in specialists in the field to help them. In some cases the institution may have a purchasing agent who insists on supplying the

furniture and movable equipment, and so plays an important part in the interior designing. With this in mind, five persons were called upon to make comments and answer questions in connection with the interior design aspects of library lighting. Two of them could not be persuaded to contribute, including one who was a college purchasing agent; of the remaining three, one was a representative of a large architectural firm that prefers to do its own interior designing; one had spent many years representing a supply house for library equipment and has probably helped with as many libraries as anyone who could have been found; and the third is an interior designer who has specialized in library work. The following general comments were received from two of these three persons:

One consultant wrote, "I don't believe I have ever seen a building program that adequately tackled the problem of lighting."

Another reported: "I suspect that different illuminating engineers would recommend different solutions for the same set of conditions, and unless there are mock-ups, how can one judge the relative merits even partially? So far a great deal has had to be taken on faith in the architect. While function is of utmost concern, I wonder if enough attention has been paid so far to design. There might well be areas where fluorescent lighting might profitably be supplemented with incandescent lighting. I wonder if enough exploration has been made regarding a more flexible system. It is daring to plan a new building with exposed overhead wiring, the wires perhaps in different colors. Then comes the question, why not? When one bank in New York City exposed its vault in the window, that was a radical departure from the accepted way of doing things, so why hide wiring with false ceilings? One building on which I worked was a dismal failure as far as lighting was concerned. There was a complete breakdown of coordination in the architect's office. His staff had the equipment layout showing the exact location of the book stacks and the wall carrels, but these were completely overlooked. The result was that strip lighting for the stacks was incorrectly spaced, and there were no lights near the carrels. With today's ingenuity individual lights need not continue to "fix" furniture arrangement. There are now spotlights that are movable within tracks."

The questions and answers for this group follow:

Question

What aspects of lighting and what requirements or specifications for it should be included in the programs submitted to the architect by an institution that is planning library construction? Should the program specify the type of fixtures, lighting patterns, and intensities for different parts of the library? If so, what are your suggestions in this connection?

Answers

1. The quality of library lighting should be of utmost concern. It is a difficult and complex question, and one that has not always been satisfactorily solved, even with the greatest care and ample financial resources. It is difficult to suggest a definite lighting fixture or lighting pattern when dealing with library buildings in general. Reading areas, stacks, and areas for technical processing in particular should be covered by a building program.

2. The only requirement that should be included in the preliminary program submitted to the architect by the client would be a general listing of desired footcandles for the primary areas in the library. This would include general lighting levels for the following spaces: reading room areas, book stacks, administrative offices, technical services, graduate and faculty offices. Preferably these criteria should be expressed in ranges of footcandle levels, such as 50 to 60 footcandles at 2′6″ from the floor, and it should be recognized that these criteria are stated as ranges and also without any reference to reflectivity or brightness factors. Types of fixtures or lighting patterns should not be included.

3. I am not always consulted by the architect on lighting, but I like to be. If I am not, my job is to inquire and learn exactly what he has specified. This can be done by examining his electrical drawings, reflected ceiling plans, and his architectural specifications.

Question

Do you have specific views on the desirable minimum and maximum light intensities, prevention of glare, maximum brightness ratio of visual environment, the applicability of polarized lighting, the color of lighting, and other aspects of library lighting? Do you have recommendations for the desirable footcandle levels for the various types of areas listed in the preceding question?

Answers

1. Since the main business in a library (book stacks excepted) is reading black print on a white page, light intensities seem to be of secondary importance. I would much rather have 30 footcandles of well diffused and glare-controlled light than 100 to 200 footcandles without those considerations. Human eyes vary in light requirements. I would start with quality and compromise if necessary on present-day recommended intensities. My present opinion is that 75 footcandles (50 footcandles maintained) of well controlled light should be ample. The color of lighting should as far as possible retain color values as they appear under natural light. It should flatter the complexion and not give human beings a pallid or sickly look. Cheerful surroundings can do much to influence the mood and the power of concentration.

2. It is undesirable to state minimums and maximums for lighting intensities, glare, and brightness ratios. The color of lighting and the desired footcandle levels of certain areas should not be prejudged. We have found a vast range of acceptable

light levels depending on the situation and the specific client. We have found the following ranges in general use: reading rooms, 60 to 100 footcandles; offices, 50 to 120 footcandles; book stacks 2'6" above the floor on the vertical surface, 5 to 30 footcandles; and technical service areas, 60 to 125 footcandles.

3. The Illuminating Engineering Society recommends 70 footcandles. Lighting engineers and particularly lighting equipment salesmen argue in favor of 100 to 200 footcandles. I usually recommend 60 to 65 footcandles, maintained level at the tabletop height. Color of light is critical. Reflectance values are of course vital. Too often libraries run into a severe problem when their new furniture comes in with a high gloss finish. I often specify mat walnut in many jobs without complaint resulting. The arrangement of ceiling lights and of tables must be considered, and note taken that the angle of reflection equals the angle of incidence.

Question

Do you, as an interior designer, consult with the architect in connection with the lighting installation that he agrees on with his illuminating engineer?

Answers

1. I have not been called upon to consult with architects in regard to lighting installations. Inquiry is essential to develop the right kind of layout and color scheme.

2. There should be a broad collaboration among those responsible for the architectural design, interior design, and the electrical engineers to create good reader environment. The use of a mock-up is a fundamental tool in evaluating a variety of schemes and the effectiveness of the end result.

3. I am not always consulted by the architect on lighting, but I like to be. If I am not, my job is to inquire and learn exactly what he has specified. This can be done by examining his electrical drawings, reflected ceiling plans and his architectural specifications.

Question

Are there difficulties in your not being brought into your assignment early enough in the planning process?

Answers

1. There are always difficulties if one is not brought into an assignment early enough. Such difficulties are not limited to lighting.

2. It is extremely difficult to design a building in which all the decisions on the light levels, layouts, and fixture types have been predetermined. The natural outgrowth of the building design process would be to take fundamental lighting criteria along with the program demands and to develop a logical, realistic environment.

3. My job is more difficult if I am not brought into the job early. I wish librarians, boards, and architects would realize the importance of complete coordination from the beginning.

Question

What role does the lighting installation play in the design of the aesthetic aspects of the building? What, for instance, is its effect on the color and tone relationship between ceilings and the interior and exterior walls? What are the requirements or problems when window openings present high intensity light contrasts and in winter when snow glare is involved? What effect on your work stems from the various tinted glass possibilities or from recessed windows or architectural overhangs which reduce direct sunlight in reading areas and in studies or carrels with various exposures?

Answers

1. The lighting installation affects the equipment layout. It dictates the location of the partitions forming departmental offices and workrooms. It sometimes influences the direction of the book stack ranges. Severe contrasts in tone—walls, floors, equipment, and so forth—must be carefully controlled. Where comfortable usage is concerned, an anemic interior is as objectionable as one with high drama. If usual recommendations for light reflectance values for walls, floors, and so forth, are strictly followed, aesthetically the interior is likely to be a complete flop. Judgment and experience are required to know where and how to employ stronger contrasts. Regard for window light ought to be expressed in the early stages of building planning. The orientation of the building is important, as well as the exposure of each room. Some walls might be windowless even if they are above ground. Where there are windows the furniture layout should take into consideration natural light sources and their quality. Solutions involving tinted glass, solar screens, blinds and draperies often make a better furniture arrangement possible.

2. The relationships of colors to type and quality of lighting and the amount and type of glass areas are indeed critical in my work. Large glass areas, tinted or not, determine our decision as to draperies. Also relevant is whether glass areas have ample overhead protection outside or some sort of "pilaster fins" properly designed to get some angles at various times of the year. Also, as you mention, snow reflectance has a definite bearing in the North.

Question

As an interior designer, what order of priority would you assign to the following aspects of library lighting installations: aesthetics, initial cost, operating cost, function and quality? To what extent should operating and maintenance problems influence the design and installation specifications?

Answers

1. The aspects of library lighting are intertwined but with qualifications I would list them in the following order of importance: quality and function; aesthetics; initial cost; operating cost. The first two might with ingenuity and skill be made to fit within the limitations of the last two.

2. Assign priority in lighting to quality and function. Aesthetics are important but only if they do not interfere with the first two. Operating costs today do not vary enough except in extreme cases to matter much, that is, not enough to sacrifice function and quality. My complaint about maintenance is in the case of very high ceilings.

3. Our major concern is to provide the best possible environment for the program requirements; the environment comprises consideration of the function, quality, and the aesthetic values. The goal naturally is to achieve the most appropriate lighting system. A decision somewhere along the line must be made as to what is the primary goal of the lighting system: Is it the quality of the work or is it the maintenance cost that will be the final deciding factor in the client's mind?

Question

What emphasis should be given to other points that should be taken into account, such as flexibility in furniture layout in relation to the light sources, individual lights in carrels and elsewhere, table and floor lamps, treatment of special rooms, and so forth?

Answers

1. It is highly desirable to have flexibility in furniture layout in relation to light sources. Because of the variation in human eye requirements, experts have often recommended individual lights in addition to general illumination. But they have disadvantages. Avoid them. Shadows and glare are associated. Adjustable gooseneck arrangements seem to be wanting in appearance, and individual lights fix the furniture arrangement. There seems to be one movement to have all electric wiring come from overhead, rather than from the floor. This arrangement requires leading the wires down through poles.

2. Flexibility must be analyzed on the basis of the individual program requirements. Complete flexibility for partitioning, lighting, electrical and mechanical needs can result in extra costs. Obviously, a library needs a reasonable amount of flexibility without great disruption to lighting and electrical and mechanical systems. Lighting for special tasks or areas should be determined by their individual requirements. Consideration must also be given to changes in scale and type of lighting in a building to avoid monotony.

3. Table and floor lamps are a maintenance nuisance and should be avoided except in administrative offices, staff lounges, and so forth. If "decorative" lighting is desirable, it should be done with ceiling-hung, pendant fixtures. Interior decorators have a mania about spotting table and floor lamps all over; in a library

this profusion doesn't make sense. Individual carrel lights depend on two things: Is overhead lighting adequate; and, how enclosed are the carrels? Shadows can result from carrel baffles or suspended shelves, but in academic libraries individual carrels are important and proper lighting without shadows is, of course, vital. Changing light types or patterns are useful for aesthetic reasons in special rooms.

Ophthalmologists, Psychiatrists, Other Doctors, Reading Experts, and Psychologists

It seemed obvious that in order to obtain satisfactory lighting, something more than its architectural, engineering, and interior decorating aspects must be considered, and representatives of the five groups named in the heading of this section were approached.

The first three groups included five medical doctors. One is a well known research specialist who has written extensively on the subject of the human eye. He provided copies of some of his publications and answered two of the questions sent to him, saying that these fell within his sphere of authority.

Question

Should librarians be worried about damage to eyes resulting from ultraviolet rays from fluorescent lighting, mercury-vapor light sources, or from direct sunlight?

Answer

There is no danger of damage to the eye from ultraviolet rays from lamps that are used for illumination. This does not apply to bulbs that are used as sunlamps where the casing is quartz rather than glass.

Question

Is there danger to health and of permanent damage to the eyes from low or very high light intensities, and can you suggest definite limits in both directions from an ophthalmologist's point of view?

Answer

There is no danger to the eye from insufficient lighting, but there is psychological annoyance and inefficiency when the lighting is so low that the reader has difficulty in making out the material. Personally, I find that 10 to 20 footcandles is adequate and 100 footcandles uncomfortable. Reading in sunlight or highly reflected skylights is downright painful. Eye strain, in the vague sense that the phrase is commonly used, increases for me with higher levels of illumination. The health hazards of low illumination are minimal, except insofar as it makes the visual task difficult and thereby contributes to a state of psychological fatigue. This fatigue is

commonly couched in the vague concept and misleading term of eye strain and is erroneously believed to cause some ill-defined damage to the eyes. This assumption is simply not true. In contrast to the relative innocuousness of low illumination, recent evidence points to ocular hazards from high levels of continuous illumination and suggests that some of the currently recommended levels of artificial lighting are approaching the hazardous level. An intensity of 1,000 footcandles is clearly in this range. It would seem reasonable to recommend illumination in excess of 100 footcandles with caution, and one might question the necessity of going as high as this. The best criterion after all for adequate illumination is probably comfort, and this is a personal matter in which the opinions of architects, engineers, physicians, and laymen have equal validity.

Two other ophthalmologists simply reported that the recently recommended high levels of illumination, that is, over 50 footcandles, while not harmful, are unnecessary except in the case of defective vision or particularly difficult reading material.

A medical research officer in the department of clinical investigation of a large drug company wrote of his interest in the effect of flickering light upon behavior and upon the basic physiological responses of the human brain. He stated that the flicker is profoundly disturbing to a great many individuals.

Although a specialist in arthritis, a doctor, who has been interested for over thirty years in library lighting and who has written articles in medical journals on the subject, reported that most people adapt themselves to whatever illumination is available if it is anywhere near adequate. He is in favor of general lighting wherever it is feasible, and is opposed to the desk lamp, which makes it impossible to obtain good lighting except right under the lamp. He is aware of no bad physiological effects from fluorescent lamps and is under the impression that ultraviolet rays do not penetrate ordinary glass. He feels that mercury-vapor light sources have little to recommend them because he finds that the colors they produce are distasteful. There is no danger from direct sunlight, unless we look into the sun. We can read under tremendous intensity of light, from 5 to 10,000 footcandles on a sunshiny day, although it may be irritating at times. He knows of no danger to health or damage to the eyes from low light intensities, although they cause eye strain, fatigue, and sleepiness. Very high intensities are irritating and damaging, particularly with direct sunlight entering the eyes. He thinks that any limit of illumination, high or low, is completely arbitrary. As a reader, he believes that 5 footcandles on the bottom shelf, 10 to 15 through corridors and lobbies, and 50 to 75 in ordinary reading areas, seem ideal, but he added that these figures are arbitrary on his part and that he is not sure they are good.

Great help was received from an interview with and the publications of Professor Emeritus Miles A. Tinker, who was a member of the University of Minnesota Psychology Department for over thirty years and the

author of some 200 publications, including 8 books dealing with applied experimental psychology of vision. Professor Tinker is an internationally recognized authority on the legibility of print, eye movements in reading and illumination for reading. The Iowa State University Press, Ames, Iowa, published his volume, *The Legibility of Print*, in 1963; the last two chapters, 15 and 16, are "Illumination for Reading" and "The Hygienic Reading Situation." In 1965 the University of Minnesota Press in Minneapolis published his *Bases for Effective Reading*, with chapters 17-20 of particular interest. They are "Physiological Factors Influencing the Hygiene of Vision," "Basic Considerations in Illumination and Vision," "Illumination for Reading," and "The Reading Situation." Anyone interested in library lighting problems would do well to read at least the chapters cited here. The following quotations from them seem particularly pertinent in connection with this study.

> With persons with normal vision acuity increases rapidly from one-half of a foot candle to 10 foot candles, and slowly from 10 to 25 foot candles. From 25 to 100 foot candles the increase in acuity is very small and has no practical significance for reading.
>
> It is questionable whether the almost microscopic gains in visual acuity obtained under the relatively high foot candles of light justify their application to visual tasks, such as reading, but those with subnormal vision have a marked increase in visual acuity when illumination is increased. Adequate illumination for discriminating details is between 10 and 30 foot lamberts for those with normal vision, and somewhere between 30 and 40 foot lamberts for those with subnormal vision. Illumination for reading should be somewhat above the critical levels. The values suggested here should be maintained. For sustained reading of material in books and magazines printed in 10 to 12 point type with satisfactory leading, use 15 to 25 foot candles; for sustained reading of small print such as 7 to 8 point type found in most newspapers, use 25 to 35 foot candles. When the brightness contrast between print and paper is 40 to 55 (medium low contrast), use 35 to 50 foot candles; with very low contrasts of 20 to 30, use 75 to 100 foot candles. The latter condition is seldom found in practical reading situations. In fact, it would be difficult to find in libraries any reading situation that would require more than 50 foot candles for adequate visual illumination. For eyes with less than normal visual acuity, use 25 to 30 foot candles for casual reading; 40 to 50 foot candles for sustained reading.
>
> In the United States the trend seems to be to specify as high intensities as the traffic will bear, and at the same time to advise the consumer that if he uses a still higher intensity, he will improve his ease of seeing. All will agree that there should be sufficient light for adequate seeing. It is important nevertheless that one should know what is adequate and what is surplus.

Professor Tinker is interested, of course, in the quality of lighting and says, "The brightness contrast is perhaps the most important factor in the hygiene of vision. For satisfactory visibility in reading there must be a high brightness contrast between print and paper. In addition, efficient and comfortable seeing depends upon maintaining proper brightness ratios between adjoining areas in the field of vision."

The recommendations for intensity made in Chapter IV of this report have been made with Professor Tinker's studies in mind, and the writer has found nothing in the works of others to convince him that higher intensities than those recommended are required in libraries.

The psychiatrist who was consulted reported that he was particularly interested in the social environment. He said, "I wish to make the case for diversity in the organization of space of a library and particularly in the terms of lighting. The library to me implies reading and reflection; they in turn imply a sense of intimacy; and intimacy implies an ability to modulate the environment and even gain a sense of its being responsive to my individual characteristics." He referred to the Hawthorne experiments described in *Management and the Workers* by F.J. Roethlisberger and W. J. Dickson, published in 1939 by the Harvard University Press, which reported that the measures of productiveness and job satisfaction change more with perceptions by the workers of interest by management in their welfare than with absolute change in the intensity of lighting.

The summarized answers which follow were received from four psychologists, two from state universities and two from private universities, and from the director of psychiatry at a health center in a large private university.

Question

The program prepared for the architect by the institution often specifies types of fixtures, lighting patterns, and intensities. Are these important from the psychological point of view and because of their effect on reading comprehension and speed? Do you have suggestions in this connection for different parts of the library, such as reading areas, stacks, offices, lobbies, corridors, and so forth?

Answers

1. Experimental findings are rarely directly applicable to the individual situation. Reading speed is certainly dependent upon some minimal level of lighting. Reading comprehension appears to be related to the reading speed of the individuals. I doubt if it depends on lighting. As for lighting patterns, keep in mind the problems of distractions and feelings of eye strain with continued reading. Certainly lighting level can and should vary in different areas of the library.

2. Architectural specifications of type of fixture, lighting patterns, and intensities are important in terms of reading effectiveness. The human eye adapts to the average level of light entering it. Therefore, the overall pattern of intensity can cause the eye to adapt to a level unsuitable for the illumination of what is being read.

3. Architecturally specified fixtures are more apt to serve the aesthetic impulses of the architect than the psycho-physiological needs of the reader. I have no objection to aesthetics but believe that special illumination should be provided where reading and writing are performed by the library's customers. Spotlighting can be a useful adjunct at 10 to 15 footcandles, but recent evidence clearly shows that where people have an option, they will select footcandle references 10 times higher than this.

4. The Illuminating Engineering Society's *Handbook* is very good on types of fixtures for different lighting situations.

Question

Do you have specific views on the desirable minimum and maximum light intensities, prevention of glare, maximum brightness ratio of visual environment, the use of windows as light sources, the applicability of polarized lighting, the color of illumination, and other aspects of library lighting, and do you have recommendations for the desirable footcandle levels for the various types of areas listed in the preceding paragraph?

Answers

1. Most of the information that I might provide along these lines can be found in the standard library sources, such as the *Handbook* of the Illuminating Engineering Society or the *Human Engineering Guide for Equipment Design* by McGraw-Hill.

2. Prevention of glare is a matter of avoiding high lighting contrast in the visual field. While polarized light sources can minimize certain types of reflection, they are not effective for direct reflections. I doubt their effectiveness would justify the added expense. Windows as light sources provide too great variation in intensity in my opinion but permit the reader to know what weather he must prepare for on leaving the library.

3. IES recommended practices specify minimum brightness levels of 80 to 100 footcandles where intense reading and writing are to be performed. This not to say that people cannot perform these tasks at lower levels. We are not talking about a matter of scientific fact, but a matter of scientific fact plus comfort and aesthetics. Glare should be prevented, of course, so as to avoid both glare discomfort and glare disability. The use of windows as light sources is a complicated business, and one usually ends up by using tinted glass or expensive shades or curtains after the building is occupied. I am always interested when I walk through a library to see how many people have elected window light to read by, though the

brightness of sunlight coming through the window may approximate 9,000 footcandles on the page of a book. How strange that people don't complain about the glare from that source.

4. You cannot depend on light from windows to be effective in libraries. The IES *Lighting Handbook* is all right on distribution of illumination. It is not as sound on intensity. The general illumination should be maintained at no less than 25 to 30 footcandles. The most severe reading tasks should not require more than 100 footcandles and rarely more than 50 footcandles.

Question

As a psychologist or reading expert, what priorities would you assign to the following aspects of a library lighting installation: aesthetics, function, and quality, if the emphasis is on reading speed and retention? Although I realize you may feel this question is out of your field, are you prepared to place priorities on these aspects because of their effect psychologically or on reading speed and comprehension?

Answers

1. A beautifully appointed and lighted library may be inviting and enjoyable to look at. I wonder if this is of importance to a person concentrating on reading. Other factors such as noise, movement, and so forth might be much more important. I would place primary emphasis on visual factors as opposed to aesthetic factors.

2. I would not care to rank aesthetics, intensity, and quality of lighting, though clearly there are tolerable variations in all three.

3. Emphasize the use of proper intensity and quality of lighting.

Question

Polarized lighting is often recommended today. Does it have any effect on reading speed and comprehension?

Answers

1. I know of no evidence or reason to expect polarized lighting to affect reading speed and comprehension.

2. There is evidence that polarization of fluorescent luminaires is helpful in removing glare in a room with many overhead fixtures.

Question

Does the widespread use of fluorescent and mercury-vapor light sources have any effect on reading speed and comprehension?

Answers

1. There are no data available in standard references or in journals on mercury-vapor light sources or polarized lighting.

2. Fluorescent and mercury-vapor sources will typically distort the perception of the hues that they illuminate, but per se should not affect reading speed and comprehension if they do not flicker.

3. This is the era of fluorescent light. Although considerably more expensive to install, its long-term maintenance advantages outweigh the lesser cost of the installation of incandescent light.

4. No, other things being equal.

Question

What is the relative importance of lighting intensity and quality in connection with speed of reading and the comprehension of what is read?

Answers

1. I am not really sure that either speed of reading or comprehension is the best criterion. Certainly they should not be the only criteria. I wonder if the average time to feel discomfort with continuous reading might not be more appropriate.

2. Increases in lighting intensity will improve visual acuity, making possible the reading of finer print up to the point of glare.

3. Both are important.

Question

Are there disadvantages or dangers in the use of intensity of under 20 footcandles, which was standard before World War II, or in high intensities of 100 footcandles or more which are found in many recently completed library buildings?

Answers

1. As we get higher lighting levels we may feel a little ill at ease at the lower ones which were once standard. The answer depends on the material to be read and the length of the reading time. I see no danger in either 20 footcandles or 100 footcandles.

2. I know of no special reasons either to fear modern increases of 100 footcandles or more, or to justify the added expense. Because the eye is rather slow to adapt to dim illumination levels after exposure to bright ones, corridors and stairways would have to be illuminated to higher levels if reading rooms were brightened.

3. You should not go below 20 footcandles, and you can go as high as you wish to pay for.

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Question

Is there any advantage in a lighting installation that is so unobtrusive that one tends to pay no attention to it unless it is called to his attention?

Answers

1. The fewer compelling attention-getters around the reader, the better. This argues for an unobtrusive lighting installation. Whether the gain is worth the cost is a question.

2. Unobtrusive lighting installation, *de gustibus non est disputandum*.

3. Perhaps.

Question

Is natural lighting and the capability of seeing something of the outside world of such an advantage psychologically or as an aid to reading that it is desirable to make it available to as many of the seating accommodations in a library as possible? If so, is there any objective evidence to support such a preference? Is it more of a factor in book stack areas, reading rooms, faculty offices, student carrels adjacent to book stacks, or in staff quarters?

Answers

1. A student can daydream while staring at a blank wall just as easily as at a scene through a window. I suggest that the closest look at the outside world from an office window is taken when one first occupies the office or when one visits it or when one shows the view to visitors.

2. I know of no objective evidence contradicting the claimed advantages of being able to see out of the window. Personally, I would like to know when to run out and roll up the car windows before the rain strikes.

3. Many people claim they suffer from claustrophobia if they have to work in a room without windows. In terms of efficiency a library without windows is much to be preferred, and my guess is that after working in such an environment, if it is well lighted and aesthetically pleasing, the complaints about claustrophobia will disappear. After all, one is not doing his job in the library if he spends his time looking out of the window.

4. Presumably one is in the library to study.

Financial Officers

Letters were sent directly to financial vice presidents, in lieu of university presidents, since the vice presidents were the academic administrative officers who were most likely to be concerned with costs and who might be expected to have a different point of view from that of the other consultants. Financial officers from ten universities that are members of

the Association of Research Libraries were written to, five in state universities, and five in private universities. Nine replied. Eight answered all or most of the questions; the ninth wrote as follows: "Our construction and maintenance departments consider the costs of maintenance of new facilities. The policy relating to them is determined by the funding available. Each building project is considered individually. We do not knowingly build facilities with inadequate lighting. We may vary the aesthetic aspects, if a shortage of funds exists, but not its adequacy. The difference in the operating costs between adequate and inadequate lighting is not a major factor. There are other ways to trim costs: the salary of one clerk pays for a considerable amount of electricity. Any objective administration will ascertain estimated operating cost for a facility—heat, air conditioning, janitorial maintenance, as well as lighting. The decisions as to the availability of funds for operations are an integral part of enlightened planning."

Two of the vice presidents, both from private institutions, wrote introductory statements in addition to answering the questions. One stated: "The lighting problems of buildings are determined by the academic needs of the departments involved. We make a review to see how a program for installations could be duplicated at lesser cost and greater efficiency. Our basic approach is one of meeting academic need at a reasonable cost."

The other reported: "...that aesthetics, reading comfort, operating and maintenance costs must all be considered. My unfortunate experience with architects is that with rare exceptions their major concern is with the aesthetics, and they don't give a fig for the operating and maintenance costs. Some even allow their creativity to carry them to such extremes that the job they give to their illuminating engineers to provide the necessary footcandles becomes well-nigh impossible. Since the illuminating engineer is normally engaged by the architect and thus "owes" something to him, I find little evidence on his part to suggest changes in the architectural concepts. The institution must then depend on its own planning and plant staff to exercise some countervailing force."

The questions and summaries of the answers with some comments follow:

Question

Are you greatly concerned about the costs attributable to higher intensity, better quality, and satisfactory aesthetic results, which almost inevitably increase costs for installation as well as for operation and maintenance?

Answers

1. We are. All these factors are part of our overall cost review of the project.

2. Yes, but some concession has to be made to reasonable aesthetic demands, and obviously the quality and intensity of light should be satisfactory.

3. No, as far as the specific cost attributable to lighting in a new library building or additions to a library.

4. The cost of lighting is not a significant item in new construction. The question that might be raised deals with such elements as specifically designed and excessively costly fixtures. Our general policy is that standardized available items should be used. Substitution of specifically designed items requires substantiating reasons.

5. No, not for the installation and operational cost of approved lighting. A far greater item is the need for air conditioning and humidification controls.

6. Yes, but we expect to pay a reasonable cost for a successful installation, including initial, maintenance, and operating costs.

7. Yes, not so much for the original installation as for the recurring maintenance and operating costs.

8. Yes, we review various systems with costs in mind, particularly those for maintenance.

Comments

Five say, "Yes," and three, "No," but one of the latter recommends standardized rather than specially designed fixtures, and a second expresses interest in air conditioning and humidification controls which are closely related.

Question

Should administrative and financial officers be directly involved in the planning of library lighting, or should this be considered a responsibility of the architect, the librarian, the engineers, and the interior designer? Should ophthalmologists, psychologists, reading experts, maintenance officers, academic building committees, and scholars participate? Can you suggest priorities among these groups?

Answers

1. Planning is the responsibility of the architect, the librarian, the engineers, and interior designers. The university planning office and physical plant department review their suggestions in the light of function and cost. The administrative and financial officers need to be directly involved. We have no opinion about participation of the other groups mentioned.

2. The owner should insist that the architect engage competent illuminating engineers. The architect, the librarian, the engineers, and the institution's maintenance officers should cooperate in determining the final standards.

3. The finance officers should be concerned with the projected cost of the building if it is out of line with similar buildings, and they should be satisfied that

the plan is sound and justifiable.

4. We rely upon the standards developed by the lighting industry and make sure that competent lighting engineers follow and achieve them.

5. Administrative and financial officers should not be directly involved in the planning of library lighting. However, it is desirable to have as many technical specialists represented in the decision-making process as possible.

6. We should review the results, particularly in regard to cost. The other persons mentioned should be consulted during the planning, as should students and faculty.

7. A great many specialists should be involved.

8. The librarian, the architect, and the electrical engineer should make the final decision. The others can be brought into the picture, but their proposals should be evaluated and accepted or rejected by the librarian, the architect, and the electrical engineer.

Comments

There is general agreement that various groups should be involved, but three of the eight hesitate to be involved themselves.

Question

Before raising or committing funds to build a building, to what degree should financial officers judge the relative costliness of the lighting system and challenge the design if it seems an excessively large part of the budget?

Answers

1. This question should be answered before the project is approved by academic officers.

2. They should question the relative costliness of any feature of the building. The situation becomes extremely sticky when it involves the architectural concepts.

3. They should be concerned. If the costs are out of line with similar buildings, they should find out the reasons and be satisfied that the plan is sound and justifiable.

4. Any lighting system and design which seem excessive should be challenged and resolved before committing funds for construction, but as to lighting per se, this would be an extraordinary situation.

5. The cost of lighting is part of the entire study of a given project and is one of the many alternative considerations that must be made.

6. At this university the building committee works with the architects and engineers, and the only questions ever raised concerning the cost were by the university staff members.

7. Financial officers are charged with setting the overall budget for a project. The cost is arrived at through consultation with their physical plant officers and

the architect. Once it is agreed upon, the architect is obligated to adhere to it. If it is necessary to extend the budget, the increase is made only with the consent of the financial officers.

Comments

The financial officers agree that they have responsibility here and should be prepared to act if necessary.

Question

Should the university be prepared to pay at the time of construction for a wiring installation and conduits that will make possible future changes in space allocations and will anticipate the additional requirements for electric current for computers, other machines, and increased light intensity? Or is provision for such flexibility too costly from the business management point of view?

Answers

1. This should be dealt with on an ad hoc basis. We build in wiring installations and conduits in anticipation of future needs.

2. I question the ability to foresee all possible needs. I would be cautious about overloading costs at the beginning.

3. Careful consideration should be given to possible future needs. Action taken must be a judgment decision considering all the factors involved. A provision at the time of construction can be far less costly than doing the work later, but the added initial cost might be unjustifiable simply to provide for a remote possibility.

4. Allowance for increased loads is ordinarily provided in new construction, but spare conduits or conductors are justified only if greatly increased loads are expected within the next few years.

5. Provision should be made for identified future demands.

6. Additional requirements should be installed for computers and machinery which are expected, but not those for space relocations or increased intensity, as every wiring system has some flexibility built into it and further increase would probably be wasteful.

7. It is generally impossible to anticipate far in advance and install conduits for possible future changes, but in a new building installations that may be required later can be placed in vertical shafts and suspended ceilings.

8. To design for extremely extensive flexibility is too costly. We limit our future provisions to installing conduits and equipment which, if installed later, would require extensive demolition.

Comments

Future needs should be kept in mind and the possibility of inexpensive

changes provided for, but not carried to extremes. This seems to be a feasible solution in most cases.

Question

Do you have lighting and other operating costs of buildings estimated before contracts are signed for construction, and, if so, how is this accomplished? What emphasis do you put on the cost of the lighting design and its relation to the electric current bill and fixture cleaning and tube replacement charges? Would you challenge a lighting design that would require erection of staging to change light tubes and clean the fixtures? How much attention should be paid to the cost of installing library lighting and its maintenance and operation?

Answers

1. An estimate is furnished by our building maintenance staff, and the cost is considered in approving the building project. We review the cost of the design from all standpoints, but academic needs would be a major factor in the final decision. We consider past performance of existing systems as to quality of light, operating costs, relamping costs, and strive for the most efficient system.

2. We do not estimate the building and operating costs but attempt to get an average figure for all buildings. We meter each building and have found that the more modern buildings, because of excessive glass, require more heat in the winter and more air conditioning in the summer and more shading throughout the year to minimize the variations in light intensities. We depend on our planning and operating staff to catch a design that would result in excessive labor for simple cleaning or replacement of bulbs, but their suggestions would probably lose ground to the architect's aesthetic arguments. We are increasingly concerned with the rising cost of operating and maintaining all academic buildings and lighting is one of the most important aspects. Since 1960 we have added 60 percent to the gross square foot area of our academic plant, and the total electric consumption has increased by 206 percent. This is not all due to lighting, but it has contributed a substantial portion thereof.

3. Our superintendent of operation and maintenance estimates the operating costs before the building is constructed. This includes the total space occupied and the electrical load, including air conditioning capacity. The department conducts studies of the relative costs of different types of lighting as they affect the electric bill, fixture cleaning time, and heat generated. We would challenge a design that required the erection of staging to change light tubes and clean fixtures. But this does not mean that we would disapprove such a design if we were convinced that it was justifiable. A great deal of attention should be paid to the cost of library lighting installations and their maintenance and operation. Every effort should be made to keep such cost as low as possible without compromising a sound and adequate plant since money spent in operating and maintaining the lighting system is not available to purchase books and other materials.

4. We estimate lighting and other operating costs on new buildings and compare the square foot costs of the contemplated structure with our experience in

existing buildings of similar type. Good quality lighting frequently requires high fixture mounting. Portable staging for lighting maintenance is standard practice on this campus. We do not compromise intensity and quality on a cost basis but are quite sensitive to the heat factor and its relation to air circulation and environmental controls, and try to balance our design without sacrificing required intensity and quality.

5. All operating costs of buildings including lighting are estimated during the preliminary phases of architectural development on a basis of cost per square foot. The estimates are basically made by comparison with actual cost of other buildings of like function. The building plans are checked by our plant manager. Among his concerns are ease of cleaning and replacement. Good grade lighting fixtures come first. We do give attention to overall cost of a lighting installation, but we must expect to pay a reasonable price for the results. An estimate is provided by the physical plant department. The owner must, of course, expect to pay a reasonable price for the results desired.

6. We try to minimize the cost of lighting, but this may be modified to obtain specific results insisted upon by the architects and the departments concerned. Fixture construction is reviewed for ease of maintenance and questionable lighting levels are challenged. We arrive at a standard and quality of illumination which meet the requirements for the task as set forth by such professional groups as the Society of Illuminating Engineers, whose recommendations are weighed, and investigate other installations to observe their results, finally establishing an agreed upon lighting footcandle requirement.

Comments

In most institutions estimates of operating and maintenance costs are made by the maintenance department, but they are generally based on past experience with similar buildings. Of course, the emphasis is put on different phases of lighting in different institutions.

Question

Does the university have lighting standards for fixtures and intensities, and are these issued by your business office, physical plant, or planning office?

Answers

1. The university has general lighting standards for type of fixtures used and light intensities to be provided. These standards are determined by our planning office and physical plant department and are subject to individual adjustments as needed.

2. Our operating plant division has lighting standards which it attempts to meet. We seek standardization of fixtures and try to have such standards included by the architects in the specifications. With a limited maintenance force, it is important that they are not presented with too many variations as this reduces the inventory of spare parts.

3. We have standards for lighting intensities to be provided in new construction. They vary with the use of the space. We do not have standards for the fixtures. The standards for intensities are issued by the planning office.

4. Intensities and quality of lighting are designated by our office of architects and engineers following general lighting industry standards. Fixtures are normally selected by the project architect and reviewed by our architects and engineers.

5. Our lighting standards are constantly reviewed and upgraded. The responsibility lies with the university architect's office.

6. No.

7. Yes, lighting standards result from discussions among our planning office, the librarian, and the project architect. If a decorative lighting effect is desired by the architect, he researches it. We may disagree with his selection if its cost is disproportionate to its position in the overall budget and the case is reviewed by administrative officers.

Comments

University lighting standards provided by the university architect, its planning office, or physical plant, are in general use, but one university reports that it follows lighting industry standards; one that the planning officer, the project architect, and the librarian would determine them for a particular library project, and one reported simply, "No."

Question

Is the university administration concerned with the reaction of students and staff if one building on the campus has been designed for a greater intensity of light than is typical in surrounding buildings?

Answers

1. We would not expect a negative reaction, except where the lighting provided was inadequate for the purposes of the building.

2. We have not had any particular student or faculty reaction to differentials in lighting standards. But relative deprivation can be a source of trouble, and this may be one of the areas for confrontation in the future.

3. We have not been concerned with the reaction of students and staff if one building on the campus has been designed for greater intensity of light than is typical in surrounding buildings. To the extent possible we update our lighting in older buildings to meet minimum standards. The students and staff accept the fact that newer buildings have better lighting and other features not present in the older ones. We would not want to avoid pressure to upgrade and improve existing conditions by compromising what we do in new construction and renovations.

4. Lighting intensities in older buildings are being improved to present-day standards on a continuing basis. Staff and student complaints often accelerate and give direction to the improvements.

5. We try to improve the level of lighting in our older buildings while at the

same time providing the greater intensity of light now desired in the newer buildings.

6. We have been challenged from time to time when students and staff go from a building with better lighting to other buildings with old and unacceptable installations.

7. No, but we have a program for upgrading lighting in older buildings.

8. We are concerned, and the physical plant department is continually making recommendations to update lighting systems in older buildings. It is customary for universities to try to upgrade the lighting in older installations, but so far there seem to be few complaints as the users understand the situation.

General Comments from Financial Officers

As would be expected, there is a considerable variation in the attitudes of financial officers toward lighting problems. On the whole they are interested in costs and the reasons for increased costs, but they feel that they must rely on experts for recommendations. Some universities simply follow the standards set by the Illuminating Engineering Society. The private universities queried seemed to be more interested in costs than the tax-supported ones.

Maintenance and Physical Plant Officers

Maintenance and physical plant officers deal with the maintenance and operation of library lighting and often are consulted on installation problems. They are only indirectly responsible for its quality, intensity, and cost, but bring to lighting a point of view somewhat different from that of the financial officers and the other groups whose views have been reported. Eight representatives were written to and seven responded.

One of the seven provided the figures used in Chapter I, page 15, to show the percentage of the total physical plant costs which resulted from the charges for electric current for lighting, for the cleaning and replacement of the lamps used and for the repairs of the installation.

Another provided a copy of a 1961 survey of lighting standards conducted by the Association of University Architects which showed that the average light in library reading rooms in 17 institutions was 63 footcandles, varying from 40 up to 150. This average was higher than in any of the other 10 academic areas studied, except drafting rooms; undoubtedly, it would be even higher if a similar study were made today.

The questions and summaries of the answers received from the other five follow:

Question

Are you concerned with the cost of electric current used in library lighting?

Answers

1. The cost is not a significant amount in the overall operating budget of a university. The library is an area in which one goes to read and study, and these two factors are of paramount importance. To be able to read without effort means lighting of adequate intensity and quality.

2. We are not concerned with the cost of electric current. The major cost problems are cleaning the fixtures and relamping.

3. We are interested in initial costs and, of course, in the costs of operating.

4. We are concerned with the cost of electric current, as well as those for the maintenance and relamping.

5. The cost of operating a library lighting system is established by the design. Freedom in design for better quality and quantity of light should always take precedence.

Question

Should lighting quality be sacrificed to provide lighting sources and ballasts that can be easily maintained? To what extent would potential operating and maintenance problems influence the design and installation of lighting?

Answers

1. The quality of light should not be sacrificed for the ease of maintenance.

2. Quality may have to be sacrificed for ease of maintenance, except where special lighting effects are mandatory.

3. The quality of lighting need not be sacrificed to ease of maintenance. Libraries are utilitarian and functional in their concepts.

4. It is not necessary to sacrifice the quality of the lighting system to provide easy maintenance. The requirements for economical and good design should complement each other.

5. Sight, mind, and comprehension time are far too important to allow any factor to influence the design of quantity and quality of light.

Question

How important is it to provide lighting fixtures that are easy to clean? What cleaning methods are acceptable? What cleaning and lamp replacement schedule is typical?

Answers

1. Once lighting quality has been attained, design for ease of cleaning should be considered. The cleaning schedule and lamp replacements are dependent on the type of fixtures and the condition of the space. Cleaning and replacements should

take place as often as necessary to maintain the intensity and quality of light.

2. It is important to maintain clean fixtures. Cleaning schedules and lamp replacements are maintained when complaints are issued.

3. The maintenance staff is conscious of the benefits of maintaining the highest possible level of illumination by periodic lamp replacements and cleaning of the lenses.

4. The quality and design of lighting fixtures have a great bearing on the ease with which they can be cleaned and sometimes may dictate the cleaning methods required. In an air conditioned building with a reasonably good filtering system, cleaning at least every two years is recommended. If the budget would permit, once a year would be better.

5. Because of the high labor costs, it is necessary that each kilowatt hour used be efficiently converted to light, thus making it mandatory that fixtures be designed for ease in cleaning.

Question

How much of the cost of cleaning can be saved by air conditioning, closed windows, and filters that do not admit dirt from the outside through the heating and ventilating ducts?

Answers

1. Totally enclosed buildings, together with a good installation of good filters and proper maintenance, can help in reducing the costs of cleaning the building.

2. Air conditioning, closed windows, and filters become more important as the environment becomes more urban.

3. We have no original data on this subject.

4. Air conditioning, closed windows, and good air filter systems result in large savings in cleaning and redecorating costs, but no definite figures are available.

5. Sealed windows, properly engineered heating, and air conditioning systems with efficient air filtering will keep at least 90 percent of the normal atmospheric dust out of the building. This does not indicate that the cost of cleaning would be reduced by 90 percent. The cost of cleaning a certain number of fixtures will remain approximately the same, but the interval of time between required cleanings would be considerably increased and the overall cost of cleaning reduced.

Question

Do you prefer hanging fixtures or those flush with the ceiling? Why? What is your view of light fixtures which include ventilation sources?

Answers

1. Suspended fixtures are less desirable for many reasons, including the fact that they collect more dirt. Lowering the fixtures does not provide better lighting. For general lighting the higher the fixture, the more uniform will be the intensity.

We prefer to install light fixtures flush with the ceiling because they are less conspicuous. Fluorescent tubes should be shielded, and the area of the shield should be as large as possible to keep down the surface intensity. We have no objection to the ventilating sources being part of the light fixtures as long as they do not interfere with the lighting.

2. Flush-ceiling fixtures are preferred as they are less obtrusive. Ventilation fixtures eliminate unsightly diffusers and keep ballasts cooler.

3. Ceiling heights usually determine whether pendant-mounted, surface-mounted, or recessed fixtures are used.

4. We do not try to influence the architects in the selection of types of fixtures, except that we recommend the use of either 4- or 8-foot fixtures of good quality. We do not have light fixtures on our campus at this time which include ventilation sources. This type of light fixture, along with some redesigning of the air handling system, will come into greater use as the footcandle level of lighting systems continues to climb. As the watts per square foot increase, we must design ways of using this energy to heat and cool the building.

5. Hanging fixtures have too large an area that catches dirt, but their use is sometimes necessary due to very high ceilings or other reasons. We prefer to have the light sources as inconspicuous as possible, the ceiling interesting but not cluttered. Today's public buildings are often designed for cooling in the central areas the year around. Therefore, designers should take advantage of "heat of light"—but this does not mean lighting designed for 200 footcandles in order to use it for winter heating.

Question

Do individual table lights or floor lamps present serious problems from your point of view?

Answers

1. We see no need for table lamps or floor lamps. If they are necessary, they present a problem in terms of cleanliness and maintenance.

2. We are not familiar with the use of table or floor lamps in a library. They would be troublesome.

3. Table lights are not used as a means of providing illumination. Floor lamps might be used in specialized rooms to create a special atmosphere.

4. Individual table lights or floor lamps always present problems from the standpoint of maintenance.

5. Table or floor lamps are really only decorations and are very inefficient light sources compared to others available.

Question

Do you prefer, other things being equal, incandescent, fluorescent, or mercury-vapor lamps? What about polarized lighting?

Answers

1. No preference. The selection must be based upon solving the problems that present themselves in the design. There would have to be an overwhelming reason to consider incandescent lighting for a complete library because of the cost and the heat given off by these lamps. We would not consider the use of mercury-vapor lamps because of their color and starting characteristics.

2. Each source of lighting has its own function: fluorescent for general, overall lighting, incandescent for special areas and effects, and mercury-vapor for exterior lighting. Polarized lighting is apparently a good shielding medium, but we doubt the value of the additional expense at the present time.

3. We use a standard 40-watt, rapid-start, fluorescent, warm light lamp in practically all of our installations. Serious consideration should be given to the use of mercury-vapor lamps in the future for special situations, such as high ceiling lights, but we will not consider this form until such time as the industry has provided quiet operating ballasts. The benefits of polarized lighting are so hard to evaluate that nothing positive has come out of our test installations. The color under polarized light has been far superior to that under conventional fluorescent lighting.

4. Not all things are equal in the case of incandescent, fluorescent, and mercury-vapor lamps, but if it were possible at this time, we would prefer mercury-vapor due to its long life. The cost of labor is generally a big factor. We have not had any experience with polarized lighting on our campus. At this time cost is a primary factor in holding back the widespread use of polarized panels.

5. If other things were equal, color would be the important factor. We would accept but try to improve the mercury-vapor arc lamps for indoor use. True polarized light will probably be available within the next ten or fifteen years and may be considered a necessity as a quality factor.

Question

What standardization is desirable for fixture types and sizes, lens types and sizes, true color and wattage?

Answers

1. Where standardization is possible without affecting the design, it should be used because it affects the cost of maintaining the system. One might think that one should use a tube which provided the greatest number of lumens per watt, but this should be weighed against the quality of light.

2. Fluorescent lighting is best standardized in 4-foot or 8-foot channels. Lenses should be of non-yellow material, such as acrylic, and tubes should usually be warm white in color, 48 inches in length and 40 watts of power.

3. It is difficult to establish standards for fixture types because of the varying architectural, building, and aesthetic requirements.

4. We recommend using 4-foot recessed fixtures with acrylic lenses equipped

with 40-watt lamps in either cool white or warm white. Lighting consultants should have some degree of freedom in the selection of fixtures depending on the seeing task, and the architectural and decorative requirements. Footcandle recommendations may reasonably be expected to increase with the improvement of light sources which results in better seeing comfort. We recommend that all lighting systems be designed with standard fixtures, rather than with special fixtures which are built for a particular job.

5. Lighting is changing too rapidly today to standardize anything other than color, and color should be as near natural light as possible.

Question

How important are windows in library lighting, and do they present problems from the maintenance point of view?

Answers

1. Adequate library lighting can be provided without windows. The type of environment desired determines whether windows are necessary. Windows are a source of fairly high maintenance cost and therefore should be chosen very carefully.

2. Windows are not important in a library. However, the absence of windows increases insurance costs in the case of power failure and the need for emergency lighting.

3. From a lighting standpoint, windows are not considered as contributing to the artificial lighting installed.

4. Windows present problems from the standpoint of maintenance. They should be kept to a minimum with south or west exposures having solid walls.

5. A window today is an architect's prerogative, to use or not as he desires to bring within a feeling of openness or naturalness. We no longer need it for ventilation and therefore, if used, it is better sealed. We used to design lighting with consideration to windows and daylight as we do with heat loss or gain in air conditioning, but with today's high-cost libraries used around the clock, it seems better to disregard daylight and to provide a lighting design for use at night and on cloudy days. Modern plate-glass windows, if properly installed, are not too much of a maintenance problem.

Question

How much are you willing to accept in increased expenditures for electric current if it means decreased maintenance costs or improved lighting for students, faculty, and staff?

Answers

1. We would be willing to accept increased costs for current if it meant decreased maintenance costs or improved lighting quality. Energy costs are not too great for space that is maintained within reasonable intensity. While many people

may not agree, it is my opinion that general lighting ranging from 50 to 75 footcandles is adequate except for special tasks. The quality of lighting is far more important than the intensity. We should strive for sources of light that are as large as possible and in which tubes and light bulbs are shielded.

2. We would accept higher operating costs if they were not excessive.

3. We do not have any generalized statement regarding the acceptability of increased costs vs. improved facilities.

4. An increase in operating cost results in an increase in maintenance cost because if we increase the footcandle level, we increase the number of fixtures, ballasts, and so forth. Our lighting system is dependent on the economic ability of our state to furnish funds. Considering the way tax rates, interest charges, and operating budgets have increased, we often wonder when we will hit an economic limit.

5. Lighting satisfaction of students, faculty, and staff, together with a decrease in maintenance costs, make it worthwhile to accept almost any increase within reason in the cost of electric current.

Research Scholars

One important group of users of an academic library consists of research scholars, particularly those in the humanities and history. Five professors who are well known throughout the learned world were asked questions, and their answers should provide a good cross-section of the attitudes of this group. In selecting the scholars to be included, an emphasis was placed on older men who had had experience with library lighting in prewar days, as well as in recent years; two were in their seventies but still active. The questions put to them and their answers follow:

Question

In an academic library do you prefer general overall lighting or an installation of lower intensity with additional local lighting directed on the material that you read or with which you are working? If the latter, are you handicapped because it sometimes makes it necessary for you to change your position as you read?

Answers

1. Library lighting is a subject in which I am very much interested and concerning which I have firm ideas. Until recently I would have said that I greatly preferred ceiling lighting plus a table lamp that I could switch off and on when necessary as in the reading room of the New York Public Library in the early '30s. With ceilings as high as they are in most academic reading rooms, ceiling lighting that is bright enough at table level to enable me to work comfortably without a table lamp is unpleasantly glaring, but in the reading room of our university library which has only ceiling lighting plus daylight, I find the most satisfactory lighting I have encountered in a reading room. I am not sure, however, that it is safe to generalize from this. One end of this room opening on a central court is all glass. I sit

as near that end as possible and so get more daylight than can be had in most reading rooms. I have worked there only between 9:00 a.m. and 5:00 p.m. The ceiling is lower than in most academic reading rooms. I suspect that the safest general answer is ceiling lighting with table lamps.

2. In general I prefer the lower lighting intensity with the direct light on my material. I do not find changing positions any serious handicap with this arrangement.

3. I prefer overall lighting with a lower intensity and additional local lighting directed on the material being used. I do not find the latter a handicap because of problems arising from changing positions.

4. I prefer general overall lighting. Limited local lighting may restrict my posture or the placement of the book or document I am reading.

5. Persons using libraries employ varying sorts of material for varying sorts of purposes. The humanist, including the historian, is more given to consulting books than manuscripts, but persons in the social sciences, and I suppose some scientists, are more likely to use material involving figures, charts, tables, and diagrams than are some of his colleagues. I think this may make a difference in the lighting problem. The humanist scholar is more likely to be satisfied with a pool of light in which his book or manuscript is placed, whereas the person consulting tables and other sorts of things is more likely to need the generally diffused and relatively bright light, the more so when he has to keep open before him a considerable spread of paper or print. In general I prefer—other things being equal—high quality, overall lighting to a lower intensity installation with local lighting directed on the material I read, provided that the lighting is adapted to the size of the room and the height of the ceiling. A high-ceilinged room with overall lighting may be rather inefficient. I have not been, I think, handicapped in most cases by any limitation on shifting my position, although I am, I suppose, a rather restless reader. The handicap when I felt confined has been due to the furniture rather than to the lighting.

Question

When you are reading in an academic library are you usually seated at a table or sitting back in a chair holding your book or papers on your lap? If the latter, do you prefer to sit in a lounge chair?

Answers

1. I assume both positions, if it is possible. It usually isn't. I sit at a table when I am consulting a book briefly or when I am using more than one book or when I am reading and taking notes. If I have an extended stretch of reading in a single volume, I prefer to tilt my chair back, hold the book in my lap, and put my feet up. I prefer a lounge chair for the latter posture but generally avoid one for serious work, because if I sit in a lounge chair and put my feet up, I promptly get sleepy regardless of the time of day. A swivel, tilting desk chair with adequate height is the best working chair for me.

2. I am usually seated at a table with material spread out on the tabletop.

3. I prefer to be seated at a table.

4. I usually read, when I read professionally, at a table, and I do not use a lounge chair. Reading, of course, is an ambiguous term. A scholar taking notes commonly wants something on which to write. When I read for enjoyment at home I tend to lie back in a lounge chair, but I see no need for this kind of thing in a working library.

Question

Do you take notes frequently when reading? If so, are your lighting requirements affected?

Answers

1. The bulk of my reading in reading rooms is of the kind that requires frequent notetaking, although I have to do long stretches of reading.

2. I take notes frequently, and this does affect lighting requirements. If possible, I like to use a typewriter and then I need two lights, especially if I am working with a reading machine.

3. I do, but this does not affect lighting requirements.

4. I frequently take notes so I want good general lighting.

5. I take notes frequently. If the lighting is diffused, I have no difficulty. If it is concentrated on the table, desk, or a portion thereof, I find local lighting interferes with proper notetaking.

Question

Do you do most of your research work in your home or in your office, where you can adjust the light to suit your needs, or in the library? If the latter, do you do it in a general reading room at a library table, in a lounge chair, or in an open or closed carrel or a library study assigned to you?

Answers

1. Practically all my research is performed in the library. I read a great deal at home in the evening in a lounge chair but seldom in connection with my research.

2. My research work is mostly done in libraries and in a variety of rooms, but what I like best is a table in the rare book reading room. I am not particularly bothered by other people in the same room.

3. I work in a closed, private study in the library.

4. I do most of my research work at home, but a certain amount is necessarily done in a library. This varies from use of the stacks to reading and notetaking. The latter is sometimes carried on in a rare book room. Otherwise, my library reading is carried on in a carrel as I do not have a library study.

5. I do most of my research work in my study or at home, and in both situations I take notes often directly on the typewriter.

Question

If there is ceiling lighting, as in most public areas in academic libraries today, do you prefer long rows of properly protected fluorescent tubes or what is known as overall lighting or some other pattern?

Answers

1. I like properly protected fluorescent lighting.

2. Long rows of fluorescent tubes.

3. For ceiling lighting I prefer the conventional long rows of properly protected fluorescent tubes.

4. My experience with modern fluorescent tubes or blocks as ceiling lighting has been that it is eminently satisfactory, better than incandescent lighting. The older fluorescent tubes were not as satisfactory.

Question

If you prefer incandescent bulbs to fluorescent tubes, please let me know and explain why you do.

Answers

1. The most comfortable light for me is fluorescent plus incandescent. I prefer the mixture because it is closer to natural light than fluorescent alone.

2. I prefer incandescent bulbs, because they seem to be easier on the eyes. It may be that there has been sufficient improvement in fluorescent lighting to overcome this difficulty, but I do not know.

3. I do not know. Fluorescent tubes provide much softer light.

4. I like incandescent bulbs in my home. If more attractive domestic fixtures for fluorescent tubes were made, I might use them.

Question

Do shadows on the working surface in a library caused by shelves over part of the desk, table or carrel, or by your body annoy you?

Answers

1. Yes, very much so. I avoid patches of sunlight on or near my working surface. They are not particularly unpleasant but they give me painful eye strain.

2. and 3. Shadows do not bother me.

4. I am bothered by shadows.

5. Shadows on the desk or table caused by shelves annoy me enormously.

Question

In your academic library, do you prefer light colored walls, ceilings, tabletops, and floors, so as to avoid too much contrast between them and the printed page, or would you be equally content if dark furniture, walls, and floors were used?

Answers

1. I am used to working on dark tables and have a feeling that I should find a light-colored working surface unpleasant, but I don't know.

2. I prefer light colored walls; in fact, I can't remember an experience with dark ones. I suspect that I would be troubled by long periods of work in a library with dark furniture and dark walls.

3. I prefer light colored walls for psychological as well as lighting reasons.

4. I prefer light colored surroundings, but they need not be an institutional white. For example, I find the reading room where I do much work very pleasant with its light green walls and green-beige wood tables. However, much of my reading at home is done in a dark, redwood-panelled room, with dark furniture, and this does not seem to disturb me.

5. Light walls and blond furniture are mildly annoying. The simpler the walls and floor and the decoration, the better. I find, for example, the Pierpont Morgan Library curiously annoying, but this may be idiosyncratic on my part.

Question

In your academic library or elsewhere are you troubled by glare from glossy working surfaces or from lighting sources shining in your eyes or reflecting from the tabletops or from windows?

Answers

1. I am particularly sensitive to any bright lighting source on my right. If I cannot sit with a blank wall to my right, I stick a blinker or paper inside the bow of my glasses on the right side.

2. I have often been troubled by glare from the pages or the table top.

3. No, I am not troubled.

4. I have not been conscious of glare but perhaps that is merely because I have the good fortune of working in relatively glare-free areas.

5. In my study I am not troubled by glare, except in the summer when the window shades do not sufficiently soften or cut out the sunlight. In some library situations I have been annoyed by glare from nearby surfaces, working or otherwise, and in others the architects seem not to have thought their way through the relation between light pouring in at windows and the effect of this light on table, book, or desk.

Question

How important to you are windows out of which you can see as you read? Does the lack of windows annoy or handicap you? Have you an opinion as to all-glass walls? If your seat is placed so that the sun shines directly on you or on the material you are using, do you want some kind of protection from it and, if so, what do you prefer, horizontal or vertical blinds, window shades, draperies of some kind, louvers, sunscreens, or fins beyond the glass?

Answers

1. Windows with a pleasant view are agreeable but not in the least essential. I can be happy in a windowless room, but I like best of all working near an all-glass wall with a northern exposure. I cannot stand direct sunlight. When direct sunlight gets on my working surface and I can't change my seat, I am forced to block out spots of sunlight even if it means shutting out the daylight altogether. I generally have to pull down shades or draw draperies at night. I should think louvers would be better.

2. I like to have a window when I am working for a long period, but for a shorter time in running about with reference work or short periods with rare books the importance of the window is not great. I have had no experience with all-glass walls. In my study a light problem with low slanting sunlight in the winter was solved by venetian blinds.

3. I prefer windows and have them. I do not need protection from the sun because of the location of the study, but if I did I would prefer horizontal blinds.

4. I have never thought I needed to sit in a room with windows, but now that I think about it, I do believe that I spend a longer time happily in a room with windows. I have not had experience in working in all-glass walled areas so have no opinion of them. I need protection from the very brilliant direct sun from a western exposure. Venetian blinds provide a satisfactory solution for the required temporary protection.

5. I don't mind a windowless room if the lighting is equal and the ventilation is good. I don't suffer from claustrophobia, but I have a feeling that architects can't make up their minds what sort of windows they wish to install in library stacks or in walls against which carrels or desks are placed, and they don't sufficiently allow for the obvious truth that the sun doesn't stand still. Some kind of window shade, blind, frosted glass, or drapery is necessary in most cases. There are many scholars who have a feeling of claustrophobia and want to look up from the page and see that the visible world exists.

Question

If you sit by a window to read after dark, do you prefer to have some way to shut out the outside world?

Answers

1. I don't mind the outside world at night, unless it has bright spots of light in it. If it does, especially to my right, I draw the shade.

2. I like to shut out the outside world.

3. I prefer to shut out the outside world.

4. I am not in the least bothered by sitting beside a window after dark.

5. This depends on the nature of the immediate outside world. On college campuses and in cities the outside world may involve a good deal of noise and moving or stationary lights. I prefer not to be distracted by these things.

Question

Is it important to you to be able to adjust your local light intensity through the use of a rheostat or through a movable light source that can be adjusted to illuminate your reading or working surface?

Answers

1. I have never used a rheostat. I like my fixture because I can move it up and down and swing it sideways to adjust the intensity of the light.

2. It is not important to me to adjust the intensity of the light. I have not often worked in places where this was possible. Perhaps I would find it splendid if I tried it.

3. A movable light source is important but not a rheostat because I prefer a maximum of lighting at all times.

4. If I must have local light, I do want it adjustable, but I have never used a rheostat. When I travel to Europe I take a small tensor lamp with me and a socket adapter so that I may get more light than is provided in most rooms in England or Europe.

Question

Is the intensity of light on your working surface as important to you as the quality and the absence of glare and shadow?

Answers

1. Three respondents answered, "Yes, it is."

2. For me the intensity of the light is much the most important. I have to have a lot of light. With plenty of light I can read though perhaps with discomfort. If there is not light enough, I just have to quit.

3. No special comments. The quality and the intensity of the light are of primary and equal importance.

Question

If the lighting installation is so designed that it is completely unobtrusive, does it bother you? Do you prefer to be aware of the fixture and the light source?

Answers

1. I think I prefer to be aware of the source of light. Certainly when working with manuscripts it is important to be able to put the source of light directly over the manuscript.

2. No, I prefer it hidden.

3. I have never been conscious of the need to be aware of the source of light.

Question

Have you an interest in or comments on the cost aspect of academic library lighting? If you do, please let me know. The costs involved include recurring annual operation and maintenance, as well as those of the initial installation. They are based in all cases on these three principal factors: the quality of light, color, tone, avoidance of glare, elimination of shadows and other unpleasant contrasts; the intensity of the light provided; and the architectural and aesthetic aspects of the installation. Can you suggest an order of priority among the three?

The costs involved in lighting are very considerable, often as much as 5 to 10 percent of those for the total building construction and over 15 percent of the building maintenance costs, which include, in addition to those involved in lighting, those for power for other uses and also those for heating and ventilating, cleaning and repairs. Altogether these electrical costs represent a significant percentage of total institutional operating expenditures, including instruction and administration, and the same dollar cannot be used for two different things.

Answers

1. Ignorance makes me unable to answer this question, but I am concerned by the issues it raises.

2. I am incompetent to discuss the question of budget problems. Lighting seems to me, next to the possession of books and their cataloging, the most important fact about any library, and the designers of too many libraries fail to think of the readers when they install their lighting systems. In the big rooms they are likely to spend too much money on chandeliers or lighting fixtures, and so on. My feeling is that the 30 footcandle lighting installation in our undergraduate library is sufficient for this purpose, but it is not a research library. The 100 footcandle notion at one of our local university libraries is out of line.

CHAPTER III

CONCLUSIONS

This chapter states the writer's conclusions regarding the five major lighting problems that were outlined in Chapter I and were dealt with directly or indirectly in Chapter II. It has been written after careful consideration and study of the comments and answers received from the persons consulted, as well as a review of the author's own experience and a study of pertinent literature.

Since members of the advisory committee hold dissenting views on different aspects of library lighting and since no consensus has been reached among those consulted in person or by letter and among those whose writings were reviewed in the literature on the subject, the conclusions recorded here must be considered the writer's alone, and he takes full responsibility for them. The topics dealt with are quality, function, aesthetics, intensity, and costs.

Quality

The major emphasis in a library lighting installation should be quality. This aspect is far more important than any of the others. It is closely related to function and cannot easily be separated from it. If a choice must be made, some inconvenience is acceptable in order to obtain better quality of light. However, there is seldom any reason why there should be a conflict between quality and function. A first-class library building with a fine collection, a good catalog, and excellent public services will not be satisfactory without a good lighting installation.

Quality depends primarily on the avoidance of glare, unpleasant reflections, shadows, and luminance-contrast ratios that are not too high. Lighting should be appropriate and comfortable for the purpose for which it is used and it should provide adequate intensity for the particular task performed.

To avoid glare and bad reflections, care must be taken to reduce to a minimum light from any source—sunlight or artificial lamps—that shines into the reader's eyes as he reads or raises his eyes to look across the room or out a window. Light sources and glossy surfaces should be placed so that reflections from them do not strike the eyes. The tabletop finish is important, and glossy paper adds to the problem. Luminance-contrast ratios that are too high should be avoided. They come from too great a

difference in the intensity of the light shining on the book that is being read and the table working surface and its surroundings, that is, the walls, ceilings, floors, and other areas within the field of vision. If the light source can be seen from an angle of less than 45 degrees above the working surface, or if contrast ratios are too great, the quality deteriorates. Do not rely on natural light for illumination, although it is important psychologically and should be used if it does not seriously impair quality and function or add unduly to construction and maintenance costs. Remember that natural light is "for readers and not for reading," and protection of some kind against it will usually be required at least part of the time. Do not neglect quality because of the costs involved.

Function

Satisfactory functional arrangements in the library involve problems closely related to the quality of lighting. These include ventilation in its broadest terms, comfortable and suitable seating accommodations, acoustic protection, and convenient traffic patterns and service arrangements that will save time for the reader. The heat generated by any kind of light or resulting from it puts an additional load on the air conditioning and cooling (although it can help to heat buildings in cold weather). Seating accommodations will not be comfortable or suitable unless the lighting provided is satisfactory for their use. Special types of lighting can help to direct traffic, and concentrated seating accommodations in a book stack (often called "oases") can well be indicated by a change in the lighting pattern. Color can be an important factor and can affect quality, function, and aesthetics. Noisy ballasts and flickering tubes can be very distracting.

The staff has lighting needs somewhat different from those of readers, and in some cases different installations should be provided.

Furniture designs and layouts should vary in different parts of the library; they often complicate the lighting situation because flexibility in the lighting, as well as in other functional aspects, is desirable. With the rapid changes in methods of library operation and use that have characterized recent years and can be expected to continue at an even more rapid pace, it is important to provide, as far as is practicable, an installation that can easily be altered for future needs. Flexibility in lighting then is highly desirable, though it will increase costs of installation, as well as of operation and maintenance. Flexibility is an important part of function. It should be added that completely uniform arrangements, even with light of high quality, may tend to be unpleasantly monotonous and may produce mediocre results. Function and flexibility in lighting installations should not be sacrificed in order to cut costs.

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Aesthetics

Aesthetic considerations are important but, if a conflict arises, should be subordinated to quality, function, and satisfactory intensity in lighting. An institution can follow any of the following courses in dealing with the aesthetic aspects of lighting:

1. It can leave them completely in the hands of the architect because he is held responsible for satisfactory aesthetic results.

2. It can try to coordinate aesthetics with the other factors and construct the least expensive installation that provides the quality desired.

3. It can set an upper limit on the building's total construction cost and then keep in touch with the architect, requesting him to refer all decisions on lighting to the institution. As was stated in Chapter I, changes in lighting requirements are too often the easiest way to cut construction costs when a reduction is necessary because bids have come in higher than estimates and available funds. Poor quality light that is unacceptable may result.

4. It can decide on suitable compromises among the three alternatives listed above. If proposed reductions in lighting costs impair quality, it will be a serious mistake to accept them. If they affect aesthetics only, the institution should decide whether it accepts them or reduces costs in some other way.

Intensity

Intensity, as was indicated in Chapter I, is more controversial than quality, function, or even aesthetics. It is also easier to measure and may affect costs as much as the other three combined, although the matter of costs will not always hold true as far as aesthetics are concerned. Yet the consultants disagreed in regard to it. The writer's conclusions can be summarized in this way:

The intensity to be used should be decided after careful consideration of its effect on quality, function, and aesthetics, as well as on the costs, which should not be unduly emphasized. There is no doubt that intensities as high as those that are often used today, 75 to 125 footcandles, may add slightly but still measurably to the ease, speed, and accuracy with which difficult material is read. They inevitably increase costs, and the writer questions the necessity or desirability of going beyond the 30 to 35 maintained footcandles at table height in most reading areas. In his experience greater intensities have not seemed to be helpful for a majority of the readers in most of their work. On the other hand, as the recommendations in Chapter IV indicate, higher intensities can properly be installed in staff work areas, in map, archives, and manuscript rooms, at the card catalog and the service desks where great attention to detail is required, and in a

small percentage of the reading areas for use by those who prefer brighter light or have defective vision. These latter areas should be in separate rooms or at one end, preferably the far end, of a large reading room where few people will notice the difference in intensity if it is not called to their attention. The higher intensity, however, should not be much more than twice that in the rest of the room; if greater than that, the area with higher intensity should be separately located. In entrance lobbies, toilets, and corridors, the lighting can be of lower intensity than in the general reading areas.

The construction, however, should make it possible to provide intensities higher than 30 to 35 footcandles almost everywhere without completely new wiring or expensive structural alterations. Heavy-duty wiring, for services that may later be required as a result of desirable changes in library use, should be available in parts of the building. Changes in space assignments which require electric current for machines and other purposes should also be possible without difficulty. A decision should be reached as to how far to go in order to obtain greater flexibility for future use; this matter is important. The extra cost of providing for flexibility at the time of installing the conduits will be comparatively small.

Architects generally insist that their interest is in the quality and aesthetic aspects of lighting, but they tend to leave the question of intensity to the illuminating engineers, although many of them decry the results in libraries that have installed intensities of over 100 footcandles. They rarely object to the 30 to 35 footcandles proposed here if supplemented by higher intensities when and where they are useful.

Illuminating engineers, whether members of an architectural firm or called in by a firm as consultants, either carry out the directions of the architect on the basis that it is his responsibility to design what will be the most suitable installation, or—when asked to prepare working drawings and specifications without receiving specific directions—follow the recommendations of the Illuminating Engineering Society in its latest *Lighting Handbook*. Like all engineers, they quite naturally provide a margin to make sure that the intensity does not fall below the specified amount.

Members of the medical profession are interested primarily in the quality of the lighting provided but believe that comfortable reading requires greater intensity than was available in many prewar buildings. They hesitate to comment further. Specialists engaged in eye research insist that intensities that are too high or too low or even of poor quality do not have any permanent effect on the eye, unless the extremes of intensity are great. Research is now in progress on upper and lower intensity limits that can be used without permanent eye damage, but no definite conclusions have been reached. Ophthalmologists report that practically any material used in libraries can be read comfortably and without harm at intensities of between 15 and 30 footcandles, provided the quality of lighting is good and

the reader does not have defective vision. They agree, however, that higher intensities should be available in areas intended for older persons and those with defective vision and in certain sections of the library where difficult-to-read material is being used. The writer's experience in many libraries confirms these conclusions.

No clear recommendations on lighting intensity could be obtained from psychologists and reading experts, except those written by Professor Miles Tinker noted in Chapter II, pages 49, 50.

Building maintenance officers may complain about the operating cost of lighting installations and ask the librarians to be more careful about the amount of current used, but in general they seem to have little influence.

Financial officers report that, while they are interested in costs, they regard the details of lighting installations as beyond their ken and refer them to their building maintenance officers, architects, or illuminating engineers.

Research scholars vary greatly in their reactions to light intensity. If they have a satisfactory quality in the areas where they work, they do not complain, and their opinions naturally reflect their own habits. The older men are inclined to think that quality and intensity are closely related. Many of them like to sit with a local light coming over the shoulder. In reading rooms without local light sources, these readers seem to prefer general overall illumination and daylight, if it can be provided without glare and reflections.

Most college students pay little attention to intensity if the lighting installation is of good quality.

The reactions of these groups have not been as helpful as the writer had hoped.

Costs

An institution may be forced to cut its lighting pattern to match the funds available. Basic decisions in regard to costs of lighting which are involved in a library building project must be made sooner or later. The costs to be taken into account include those for the original lighting installation and, more important in most cases, the costs of operation and maintenance that come after the building is completed. The costs in question are fairly large. Between 3 and 8 percent of total construction costs, and between 15 and 30 percent of the building maintenance costs might be considered the typical range. It should be remembered that the whole library operation—construction, maintenance, service, acquisition and cataloging of collections—is an expensive one, and that it is also a very important part of the educational program of the institution. Obviously it is foolish to spend 5 percent of the institution's current budget, to say nothing of 10 to 15 percent or more of its total capital investment, for a library building, equipment, and service, and then to decide that only second-rate lighting

can be afforded. Since the top officials are responsible for deciding what should be done about lighting, they should consider the available evidence, a detail which is often overlooked.

Summary of Conclusions and General Comments

This section represents the writer's conclusions. He wants to emphasize again that the costs involved in lighting are large enough so that they should be very carefully considered in relation to other expenditures and that, at the same time, a good lighting installation is so important that it should not be jeopardized by or sacrificed because of financial considerations or penny pinching.

Extra expenditure, to provide a quality lighting installation that will attract patrons and insure flexibility for later inevitable changes in spatial arrangements and services, will be well worthwhile. Lighting may be an easy place to economize, but it is often not a good one as far as the original construction is concerned. The cost of maintenance and operation is even more important in the long run.

A satisfactory lighting installation and operation does not necessarily mean an expensive or elaborate one, but it should not be aesthetically displeasing. Equal intensity is not required everywhere. In the writer's opinion, it is less monotonous and more pleasing aesthetically to vary the intensity for different areas, making each suitable for the particular use to which it is put. Make sure that the intensity is high enough in the limited areas where poorly printed books, manuscripts, and other difficult-to-read materials are used, especially when these materials, because of their value or because of seating arrangements, cannot be shifted to another area without complications and inconvenience. This principle holds for both readers and staff. But, in the great majority of seating areas and throughout the main book stack, lower intensities are adequate so long as the user, because of age, defective vision, or personal preference, is able to take a volume selected from the shelves to a carrel, a lectern, or an area with higher intensity. If the percentage of seating areas with the higher intensities proves to be too low, the required alterations should not be unduly expensive to make, as long as the electric conduits can provide for an increased wattage where and when desired. As will be shown in the Table on page 90 the use of the lower intensities in much of the building may save half of the annual cost of operation and maintenance of lighting and add nothing to the original installation cost, beyond that amount provided in any case to make possible desirable flexibility.

As has already been stated, this report is nontechnical in character. It does not deal with the relative merits of polarized lighting, incandescent bulbs, fluorescent tubes, or mercury-vapor and sodium-vapor lamps, except as they relate to function, intensity, and costs. This technical information is available in the Illuminating Engineering Society's *Lighting Handbook*

and from consulting and illuminating engineers. The report does not discuss color in its relation to aesthetics, although this is undoubtedly an important aspect of lighting. Like other aesthetic problems, color is partly a matter of taste and, to a lesser extent, of current style. The report contents itself with the basic lighting problems of quality, function, and flexibility, the importance of aesthetics and suitable results, the costs of installation, operation, and maintenance, and the interrelationships of these factors.

The major emphasis should be on quality and suitability for each area. Recommendations based on these conclusions follow in Chapter IV.

CHAPTER IV

RECOMMENDATIONS

General Recommendations

1. A decision on the quality of the building and a statement of the funds available, if the amount is definitely limited, should be made by the institution before the program for the architect, which specifies other requirements, is approved. Having been informed of these decisions, the architect will then have some idea as to how far the institution is prepared to go if the new structure is to include anything beyond the bare minimum for a plain, factory-like building. The architect should report promptly to the institution if he has been asked in the program for elements that are undesirable, impractical, or impossible. Extras may include, among other things, sturdier construction, better quality, aesthetic features, increased comfort and convenience for the users and the staff, and satisfactory atmospheric conditions for both these groups and for the collections. None of these should be forgotten.

All architectural projects involve compromises. The same dollar cannot be used in more than one way. Decisions should be made with all available facts at hand. The architect or a consulting cost estimator may sooner or later suggest changes in details specified in the program. The changes may be good ones, but the institution should know why additional funds are required, if they are, or how costs can be reduced, if they must be. Economizing in the wrong places should be avoided and the institution must decide what are the right places given its circumstances. Quality of lighting is important and should not be subordinated. It should be searched for diligently. Do not neglect it, but remember it does not necessarily result from higher costs and may be impaired by high intensities.

2. Keep in mind and continually emphasize that satisfactory lighting plays a large part in making a comfortable, convenient and attractive place to work, and that good lighting is essential to a good library as an aid to reading speed and the comprehension and retention of what is read. Light, to be satisfactory, must be of high quality. It must not come from a source shining in the eyes, nor should there be glare and reflections, shadows, or too great contrast between the reading surface and its surroundings. Light must be suitable in intensity for the area that it illuminates. As experience has often demonstrated, high intensity alone is not the solution. If high intensity is provided, it must be combined with high quality or the installation will be unsatisfactory.

3. A functional lighting installation is nearly as essential as a high quality one and functionalism may properly be considered an important part of quality. Flexibility, which will provide satisfactorily for changing needs in the years ahead, is closely related to function.

4. Aesthetic aspects in library lighting construction may have to be subordinated to quality and function, but they are important. Although many students and scholars are so wrapped up in their work that they seem oblivious to quality, function, and aesthetics, they may still be subconsciously attracted to the library by them. Others are definitely influenced by these factors, some by quality and function, some by the aesthetic effects, and some by all three.

5. A library building should be wired throughout in such a way that the available wattage can be increased without drastic alterations to the basic wiring. This capacity for increased wattage will provide flexibility in space assignments and relationships. It will also add comparatively little to the cost if decided upon in advance and may well prove to be an economy in the long run as needs and demands change. It may also be useful if better quality light becomes available in the future from fixtures that decrease intensity. This has sometimes happened in the past. (It should be noted, however, that the effectiveness of light sources, including the intensity made available by them, tends to increase year by year with new technical advances, and that the cost of electric current has tended to increase less rapidly than most other things in inflationary periods.)

6. A small amount of carefully selected square footage in the library should be wired so that new installations requiring high wattage apparatus can be installed without extensive alterations. It seems doubtful that more than 2 or 3 percent of the library area will ever be needed for this use. The original installations—with the additional wattage possibility recommended in the preceding paragraph—would be adequate to provide more audio-visual carrels if they prove to be needed. It is doubtful that study space for the use of audio-visual material will replace a very large percentage of present reading accommodations in libraries in ths next generation; instead, the expected increase in use of audio-visual materials will require a larger percentage of the additional accommodations that will be needed. A similar situation will hold for automated services of various kinds. Changes in library operations will continue rapidly in the years immediately ahead and probably indefinitely; librarians should be prepared for them and should not oppose them when they promote the educational program.

7. There are few reasons, if any, based on quality, function, aesthetic requirements, changes in wiring installations, or the reorganization of library service that will require completely uniform intensity throughout a

building so long as flexibility in space allocations is available and a reasonable margin for an increased amount of current is provided.

8. Recommendations 1 through 7 should be kept in mind in making decisions on the more controversial lighting problems, that is, intensity and cost.

Recommendations Connected with Intensity

1. A variety in readily available lighting intensity in different library areas is useful in order to avoid monotony, which many persons find undesirable, either inside or outside a building.

2. Wiring should be installed so that flexibility in library spatial assignments will be easy to obtain. Light sources should not be placed so far apart that shadows resulting from equipment prevent desirable and space-saving layouts.

3. No two libraries are alike, and the specific figures for intensity, as well as costs for installation and maintenance and operation, vary from library to library now, and this variance will undoubtedly continue to be the case. The formulas given below suggest one possibility and should help engineers to figure out the results in a particular location under the selected intensities.

4. Proposed furniture layouts should be checked with the lighting drawings to make sure that undesirable shadows from partitions, carrel shelving, or book shelving can be avoided. Transparent overlays of the lighting fixtures superimposed on the furniture layout drawings will be useful; in some cases a mock-up will be helpful.

5. Make sure that furniture layouts do not require readers to face direct or reflected sunlight or glare.

6. Carrels along the periphery of any area tend to have lower intensity adjacent to the wall and may require ceiling lights parallel to the wall or cove lighting.

Specific Suggestions for Intensities in Different Areas

The author recognizes the controversial aspects of lighting intensities. He knows that many librarians, including members of his advisory committee, do not share his views completely. He puts forward the specific recommendations that follow as his personal opinions in the light of wide experience and study of the subject. He believes that his recommendations are reasonable and adequate. At the same time he also believes that the higher intensities often recommended by illuminating engineers are just as satisfactory if the quality of the light is as high as it should be and if

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those concerned are prepared to pay for the additional electric current required. He is convinced that high quality and high intensity light too often do not go hand in hand and he sees no excuse for the use of intensities so many times higher than those considered adequate and satifactory thirty years ago. In this he concurs with the recommendations of some architects, opthalmologists, psychologists, such as Dr. Miles A. Tinker, and some other interested and competent persons. Quality in lighting, not intensity, should be the first consideration.

It is suggested that the following "maintained" intensities are adequate for different areas in an average library if the quality is as high as it should be. Quality should be the first consideration.

1. Thirty to 35 footcandles is sufficient for 70 to 80 percent of the general reading areas at the working surface level on tables, desks, and carrels in reading areas and book stacks or other places where continuous reading is carried on. This intensity should be satisfactory for a great majority of persons consulting or reading most printed books, or reading or writing their own notes with a jotter or ink pen or pencils, unless a hard pencil or poor print or poor carbons are being used. The 80-percent figure should be satisfactory in an undergraduate library, but as little as 70 to 75 percent may be preferable in a research library where there is a larger percentage of material with poor print and there is more use by older or defective eyes.

2. Sixty to 70 footcandles is adequate for most of the remaining 20 to 30 percent of the general reading areas. In a room utilizing both lower and higher intensities the higher ones should be confined to one portion, preferably the far end from the main entrance and possibly cut off partially by standard height book shelving or screening of some kind. This protection is not necessary if the intensity is not more than twice as much as in the rest of the room. The higher intensity areas should include the accommodations where maps, manuscripts, archives, and rare books are used and for faculty studies and a limited amount of readily accessible space elsewhere.

3. Areas with 90 to 105 footcandles separated from general reading areas should be available for the few persons with defective vision and also for anyone who has a personal preference for it. This space should not be in the same room with intensities of 30 to 35 footcandles, but could be adjacent to areas with 60 to 70 footcandles. Few libraries should need this very high intensity at more than 3 percent of the total seating accommodations for readers.

4. Some faculty studies and locked carrels used by graduate students, if located in areas with 30 to 35 footcandles, may well have supplementary individual lamps to provide an additional quantity of light. It should be

remembered, however, that local lighting may invite vandalism and that light shining on a working surface from a fluorescent tube under a carrel shelf often tends to reflect back into the reader's eyes, particularly if the material being used has a glossy finish. If these areas have been provided with light plug outlets, the user can provide his own lamp.

5. Seventy footcandles is recommended for the staff, the catalog, and the service desks. In most academic libraries these areas include no more than 8 to 10 percent of the total library building. The higher intensity of 70 footcandles for staff members is recommended because they work long, consecutive hours with all kinds of printed and manuscript materials, and they cannot shift from the seats assigned to them without upsetting a basic functional equipment layout. Local lamps to provide part of the intensity are often suitable in administrative offices.

6. In most libraries students can and should be allowed to shift from one reading area to another at will if they prefer different lighting intensities or different seating accommodations of any kind.

7. In book stack aisles 30 to 35 footcandles should be provided on the horizontal plane at 30 inches above the floor. Light-colored floors and ceilings will help because they provide good reflecting surfaces. The stacks can be lighted in one of three ways:

a. By continuous rows of fluorescent tubes down the center of each aisle. Gaps between one tube and the next should not be more than 2 feet, as light does not extend well lengthwise from the end of fluorescent tubes. The rows are generally placed from 4 to 5 feet apart on centers, varying according to the range and aisle spacings.

b. By continuous rows of fluorescent tubes at right angles to the stack ranges, with no gaps between them. These should be used only if the ceiling height is great enough so that the lamps will be at least 8 inches above the top of the ranges, so arranged as to prevent the books from overheating. There are two advantages in the right angle arrangement. The lighting strips placed in this way make it easier to shift the ranges to a different spacing. The bottom shelves, which are farthest away from the light source, will be better lighted by right angle than by parallel strips, because the light reaches the vertical surfaces of the backs of books at a wider angle (something over twice the angle from the parallel lighting). This arrangement should not be used unless the lights are to be on whenever the library is open.

c. By incandescent bulbs not more than 6 feet on centers, used in fixtures with reflectors that will spread the light satisfactorily. They should be installed only in little used, closed access stacks or areas in which time switches turn off the bulbs automatically after a few minutes of use. Fluorescent light is of equal or better quality and, if stack

lights are to be kept on during the entire period of opening, it is less expensive for the same intensity. Emitting less heat, it also reduces the air cooling load, and, with plastic or baffle protectors or with proper color, the ultraviolet rays should not damage binding or paper.

8. Exhibition cases should be lighted so as to call attention to them and make it easier to see the contents and read display labels or notes, but special care is necessary to prevent damage from heat and ultraviolet rays, and to avoid or minimize glare. Methods used in good museum installations may well be followed.

9. Fifteen footcandles, if well distributed, is adequate for vestibules and entrance lobbies, corridors, toilet facilities, stairs, and elevators. These areas are not used for reading, and when one goes from them to the reading areas where the intensity is higher, the eye, having adjusted to the lower intensity, should find intensities recommended for the reading areas and work room entirely adequate.

10. Remember that light intensities are relative. If other buildings throughout the institution are more brightly lighted, there will be pressure for higher intensity in the library, although, when quality is good, the eyes adjust readily and fairly quickly to any intensity between 10 and 150 footcandles. A greater shift is more difficult and unpleasant.

The Table on p. 90 shows estimated comparative operation and maintenance costs for two different libraries with 100,000 gross square feet, one (A) with the variations in lighting intensity among the different areas as suggested in these recommenda' s, the other (B) with an intensity of 100 footcandles throughout. The ' r believes that the library with variations in intensity will be as satisfa ry, in some ways more attractive, and considerably less expensive and monotonous than the one with the higher intensity throughout. He proposes and recommends that a program on this general basis with variations to suit the local situation be presented to an architect for his consideration and comments. A good maintenance officer can check on the costs shown in the Table and adjust them to the local situation.

TABLE

Annual Operation and Maintenance Cost of Lighting

Use of Space	Square feet	Footcandles Maintained*		Watts per sq. ft.		Kilowatt per hour		Annual Cost (see note)	
1. Walls, partitions, etc.	10,000								
2. Lobbies, halls, toilets, elevators, stairs, lounges	15,000	A 15-17½	B 90-105	A .75	B 4.00	A 11.25	B 60.00	A $900	B $4,800
3. Book stacks	25,000	30-35	90-105	1.50	4.00	37.50	100.00	3,000	8,000
4. 75% of seating	30,000	30-35	90-105	1.50	4.00	45.00	120.00	3,600	9,600
5. 25% of seating	10,000	60-70	90-105	2.75	4.00	27.50	40.00	2,200	3,200
6. Staff and service**	8,000	60-70	90-105	2.75	4.00	22.00	32.00	880	1,280
7. Special for defective vision and difficult work	2,000	90-105	90-105	4.00	4.00	8.00	8.00	320	320
Total	100,000							$10,900	$27,200

Note: Annual cost is figured on the basis of $.02 cents for each kilowatt used. This includes maintenance and operation expenditures, with the public parts of the library, areas 2-5 open 4,000 hours a year and the remainder, areas 6 and 7, open 2,000 hours. Local conditions, including current and labor costs, will cause variations from these cost figures. Ceiling heights, if very high, will change the wattage requirements, but those used will be adequate for clear ceilings up to 10 to 12 feet if good fixtures are used.

The figures used are estimates that have been checked by an experienced illuminating engineer for a library with 100,000 gross square feet, with the different intensities proposed, if the cost of $.02 per kilowatt for combined operation and maintenance is used. He believes that the intensities proposed could be made available with the wattage proposed in the estimates and would provide a good quality of lighting. He has agreed to join with an experienced library architect to design a library lighted on the basis proposed. Work is now proceeding on the assignment.

* Includes public service areas.

** Average footcandles for area.

APPENDIX A

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APPENDIX B

SELECTIVE BIBLIOGRAPHY

"Brighten Your Corner." Radio Television Administration Broadcast No. 7464, 29 January 1967. Berkeley, Calif.: University of California.

Cogan, David G. "Lighting, Eye Strain and Health Hazards." Report prepared for the Seminar on Performance Criteria for the Luminous Environment, 6-7 July 1967, Saratoga, N.Y. State University of New York Construction Fund.

Contributions to the London Conference on Museum Climatology, 1967. Edited by Garry Thomson. London: International Institute for Conservation of Historic and Artistic Works, 1967.

Crouch, C. L., and Kaufman, J. E. "Practical Application of Polarization and Light Control for Reduction of Reflected Glare." *Illuminating Engineering* 58 (April 1963, Section 1): 277-91.

Illuminating Engineering Society. Light Sources Committee. "Choosing Light Sources for General Lighting." *Illuminating Engineering* 62 (1967): 319-23.

Illuminating Engineering Society. "Lighting for Libraries." (In preparation for fifth edition of *Lighting Handbook.)*

Logan, H. L. "Lighting and Well Being." *Catholic Property Administration* 25 (1961): 89-93.

Metcalf, Keyes D. *Planning Academic and Research Library Buildings.* New York: McGraw-Hill, 1965. pp. 175-88, 409-10.

Neisser, Ulric. "The Control of the Luminous Environment." *Scientific American,* September 1968, pp. 190-202.

Rae, Gene. "What Lighting Will Be Like in the 1980's." *Lighting and Electrical Design,* November 1967, pp. 36-37, 54-55.

Sommer, Robert "Reading Areas in College Libraries." *Library Quarterly* 38 (1968): 249-60.

State University of New York Construction Fund. "Interim Report on Performance Criteria for the Luminous Environment." A report of a research project performed for the State University of New York Construction Fund by the Massachusetts Institute of Technology. Cambridge, Mass., 1968.

Thorington, Luke, and Parascandola, Louis J. "Ultra-Violet Emissions from Light Sources Used as General Illuminants." *In* Illuminating Engineering Society. *Transactions* 32 (1967): 674-81.

Tinker, Miles A. *Bases for Effective Reading.* Minneapolis: University of Minnesota Press, 1965.

Tinker, Miles A. *The Legibility of Print.* Ames, Iowa: Iowa State University Press, 1963.

Wessel, Carl J. "Environmental Factors Affecting the Permanence of Library Materials." *Library Quarterly* 40 (1970): 39-84. (This entire issue of *Library Quarterly* is of interest. It contains the Proceedings of the Thirty-fourth Annual Conference of the Graduate Library School, University of Chicago, August 4-6, 1969. All of the papers are on the topic of the deterioration and preservation of library materials.)

Wood, Frederick C. "Cost Control in Design and Construction." Address presented at the Twentieth Annual Engineering Conference, 2 May 1968, Washington, D.C.

Wood, Frederick C. "Light Intensity Versus Cost." A report prepared for this study. Cos Cob, Conn., Wood and Tower Inc., 1967.

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